EXPERIMENTAL INVESTIGATIONS OF SOCIAL BEHAVIOUR IN ANIMALS

COMPETITIVE ORDERS AS MEASURES OF SOCIAL DOMINANCE

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ABSTRACT

Competitive orders are now in common usage as measures of social dominance in laboratory studies. Their use in this capacity is based on the premise that since dominance governs all priorities to resources within a group it is irrelevant as to which of these is chosen as its index. As a result methodological aspects of competitive measures have been neglected and most studies finding reliable orders on competitive tasks have reported these as being dominance orders; often without presenting social validations.

The validity of the competitive measure is, therefore, clearly based on the assumption that dominance can be regarded as a unidimensional concept. But many of those laboratory studies which have presented relationships between aggressive and competitive orders or have used more than one competitive test have found evidence that this is not the case.

This thesis investigates the validity of competitive measures of dominance in three species: the New Zealand ferret, the laboratory rat, and the domestic fowl. In general it is found that competitive orders for both ferrets and rats should not be regarded as measures of social dominance. Further work is required on the analysis of the competitive behaviour of the fowl before the concept of dominance can be meaningfully applied to the competitive behaviour of this species.

The general problems of the validation of competitive orders and the use of the concept of social dominance are discussed.

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C H A P T E R O N E

I N T R O D U C T I O N

CHAPTER ONE

INTRODUCTION

Social dominance was introduced as a description of the social organisation of the domestic fowl by the Norwegian naturalist Schjelderup-Ebbe in 1922. This author noted that in flocks of the domestic fowl aggression exhibited between any two animals was unidirectional. The animal which consistently emitted the aggressive responses was labelled the "despot" or the dominant animal, whilst the animal which was pecked was regarded as being the subordinate. As a concept, dominance immediately became popular, so much so that by 1939 Crawford reported that it had been applied as a subject of study to all vertebrates except fish and amphibia. Since that time it has been generalised to incorporate not only fish (Braddock, 1945; McDonald, Heimstra and Damkot, 1968) and amphibia (e.g. Haubrich, 1961; Boice and Witter, 1969) but invertebrates (e.g. West, 1967; Ewing, 1972) as well.

Although Schjelderup-Ebbe's original studies were entirely observational in nature and his orders were described solely in terms of overt aggression, it is apparent that he regarded this behaviour as the outward manifestation of an underlying social organisation which governed all social behaviour in the fowl. "Between any two birds .. one individual invariably had precedence over the other" .. and .. "In this case z is the despot, the superior being, the tyrant; he has the power and may use it as he pleases" (Schjelderup-Ebbe, 1922). This view of the phenomenon of aggressive orders has since undergone very little change. In a recent review of

social dominance van Kreveld (1970) still regards overt aggression as the primary index of dominance and defines dominance as "a priority of access to an approach situation or away from an avoidance situation that one animal has over another." A similar view is shown by Wood-Gush (1971) in his description of the peck order in flocks of the domestic fowl. "High ranking birds which deliver the most threats and win the most fights also have priority for food, nests, roosting places and greater freedom of the pen." The similarity between the descriptions of Schjelderup-Ebbe and Wood-Gush is striking, and it appears that, at least for the domestic fowl, the concept of dominance has changed little since its inception. In his more general review, though, van Kreveld (1970) does note that the priority rights for access to different situations are not necessarily identical; but since he quotes only one reference in which this is the case (Kruijt, 1964) the inference is that such occurrences are exceptional.

The fact that a unidimensional view of dominance has always been readily accepted has had important methodological consequences for its study. Soon after the introduction of dominance it became clear to many authors that the measurement of aggressive behaviour could become a slow and tedious affair in those species in which aggression was rare in stable groups of animals. Assuming that this lack of aggression was due to the regulation provided by a stable dominance order, many authors then began to devise other means of measuring the phenomenon. Rêvész (1930), for instance, deprived his monkeys and then titillated them with food in order to evoke overt aggression. James (1936) used a similar procedure for his dogs. This development was closely followed by the use of

a fully competitive situation in which performance at a competitive task was regarded as being indicative of the dominance status of monkeys (Maslow and Flanzbaum, 1936). Because of the ease with which these authors obtained their competitive order and the high correlation shown between aggressive and competitive behaviours in this study, the use of competitive measures of dominance quickly proliferated and they are now commonly used as observational methods. The rationale for the validity of such orders as indices of dominance was, and still is, that since the dominance order governs all priorities in a group it does not matter which priority is measured as they are all representative of the same phenomenon.

This view of the use of the competitive index of dominance is acceptable if the unidimensional view of dominance is valid. But even though this seems to be the opinion of many reviewers a closer look at the laboratory dominance literature reveals that evidence has been available for some time that there is not necessarily a high correlation between aggressive and competitive orders in some species (see Table 1.1). Also, those studies which have used more than one competitive test have often failed to find a high correlation between the competitive orders (see Table 1.2). Thus the assumption of unidimensionality does not seem to be supported in many of the species to which the concept of dominance has been applied, and it is clear that the present lack of interest in the procedural and theoretical validity of competitive studies is regrettable. If such orders are to be regarded as measures of social dominance they must be shown to measure the priority that they claim to.

A SELECTIVE ANALYSIS OF THE LITERATURE

Although it is easy to show that dominance cannot be regarded as necessarily being unidimensional in nature, it is another matter to comprehend how the literature showing this has been ignored over the years. In order to attempt to understand this, two general reviews have been chosen for examination, along with a discussion of one experimental study. One review has been chosen from 1950, which represents the middle stages of the dominance literature, while the others are both recent papers in this area.

1. Collias (1950)

This author reports in his review "Social life and the individual among vertebrate animals" that "-individuals of low rank are often denied access to food and mates" and presents three fowl references as his justification. These were Collias (1944), Collias (unpublished data) and Guhl, Collias and Allee (1945). The first reference is, in fact, an earlier review by Collias himself; the second is inaccessible; and the third does not seem to fully justify the claims made for it by Collias. Examining the third paper briefly, it is true that Guhl *et al* found that dominant males had a higher frequency of mating than their subordinate counterparts. However these authors also discovered that there were statistically significant negative correlations between the social position of the hens and the frequencies with which they were courted by the cocks. So it would appear that high social dominance is a mating advantage for the cocks only. Thus the substance of Collias' claims in 1950 seem to rest on his earlier review. Consequently this review is worthy

of close analysis.

Collias (1944) reviews a number of laboratory or captive animal dominance studies.

(a) Monkeys : Collias gives no justification that aggressive behaviour demonstrates priority in other situations but merely states, without reference, that "In several laboratory studies precedence to food is commonly used as an indicator of dominance." Later he does quote a reference by Nowlis (1941b) who showed only that competitive performance was related to the level of motivation. But this does not justify the use of competitive measures.

(b) Cats : Here Collias quotes Winslow (1938). However this author did not find a dominance order in cats, but claimed to have shown that there was only one dominant cat and that the remaining cats, regardless of sex, were submissive to him. The evidence gained from the behaviour of this cat does support Collias' claim that it did, in fact, have prior access to food.

(c) Dogs : For this animal Collias quotes the work of James (1939). This author did find a good relationship and priority in both food and sexual competition.

(d) Fish : Here Collias quotes the work of Noble (1939). This reference was a review, and the only study quoted pertaining to the relationship between priority of access to food or mates and dominance is that of Noble and Borne (1938). Unfortunately this research was reported in abstract form only and no details of the experimental techniques used are provided. However the abstract does state that the most aggressive fish did have prior access to food. A high relationship was also found between weight and the aggressive order

(e) Turtles : For this animal Collias quotes the work of Evans (1940). Here again this paper is available only as an abstract. The evidence does seem to support Collias' claims for a direct relationship between aggression and priority of access to food. As in the previous fish study of Noble and Borne (1938), however, there was a high correlation between body weight and aggressiveness and, since there was no control for age in this study, complete interpretation is difficult.

In conclusion, therefore, although much of Collias' earlier review does support the unidimensional view of social dominance, the studies quoted from the fowl, cat and monkey literature are insufficient to convince one that dominance can always be regarded as being unidimensional in nature.

A RE-ANALYSIS OF THE LITERATURE BEFORE 1944

Collias also seems to be guilty of selecting only a few of the available references and of over-simplifying the interpretation of the competitive literature in doing so. For example, a survey of the competitive dominance literature in the Journal of Comparative Psychology up until 1944 reveals that the relationship between competitive and aggressive orders is variable, as are the properties of the two orders themselves. Eleven studies were found in all, six of these concerning monkeys. Four of these monkey studies (Yerkes, 1940; Crawford, 1940; Nowlis, 1941, 1942) looked at the effects of sexual and motivational variables upon competitive performance, and found that the competitive order was susceptible to fluctuation with changing sexual status (that is, when a

female is receptive it does better in competition with the male), changing phases of the menstrual cycle, and increases or decreases in the level of deprivation.

The fifth study (Harlow and Yudin, 1933) was concerned with relating the concept of social facilitation to that of dominance in a group of six macaques. Although they found a tenuous relationship between degree of social facilitation and overt aggressive behaviour the total amounts eaten by the subordinate animal of the only pair for which all raw data was presented (353 pieces of orange) did not seem to be less than that of the dominant (342 pieces of orange), although on most occasions the dominant ate first.

The final study was that of Crawford (1942) who attempted to relate the competitive order to social behaviour in a non-competitive situation. In this study aggression in the group was measured as well as other behaviours but only social grooming correlated with the competitive order.

The 1944 Journal of Comparative Psychology published two studies by Winslow, using cats, in which he used two different tests for measuring food competitive orders. The correlation between the two orders was found to be low. In the same journal Bruce (1941) compared food and water competitive orders in the laboratory rat and found that they correlated highly. It is most interesting that he notes that the period allowed for competition was an important variable which could well affect the final outcome of a competition. Using mice Uhrich (1938) compared food competition orders with aggressiveness in normal cage conditions. He found that "Animals that were observed to be subordinate under ordinary conditions here obtained as much food as their dominant."

Again these results would tend to invalidate the direct comparison between aggression and competition in this laboratory situation.

It can be seen, therefore, that while Collias certainly had some justification in pointing out that in many studies there was a high correlation between aggressive orders and competitive orders, he would have been better to ensure that all the exceptions to this were noted along with their possible consequences for dominance theory. He should also have dealt with the problem set by Winslow in finding a low correlation between two competitive tests. If a global type of dominance could be applied to rats as he infers in his 1950 review, a decision should have been made as to which of the competitive orders reported by Winslow was the dominance order. Collias should also have noted the comments of Bruce (1941), that the competitive order for rats could well depend on the competitive period chosen, and on this basis suggested further methodological work in this area.

To demonstrate that this tendency to over-simplify the dominance literature was not that of only one author, or of an early stage in the development of dominance theory, the second and third studies to be analysed will be contemporary papers by Baeninger (1970) and Wood-Gush (1971).

II. Baeninger (1970)

Baeninger (1970) showed that for rats the correlation between dominance orders obtained from both food and water competition and from spontaneous aggression all correlated poorly. However in her discussion this author states that these results contrast with many other studies with different

species in which dominance has been found to be a unidimensional order. The references quoted in this context are as follows.

(a) Monkeys : Washburn, Jay and Lancaster (1965) - This is a review in which dominance is claimed to be an important determinant of the behaviour of Old World monkeys. The authors do not state that this dominance is necessarily unidimensional. "Although dominance varies widely among monkeys and apes in both its form and function, it is certainly one of the most important axes of social organisation to be found in primate society."

(b) Dogs : James (1951) - Using dogs James did find a relationship between performance on a food competition task and aggression, but in this study a between-breeds comparison was being made so that the study is not comparable with that of Baeninger (1970). It is also important to remember that James, in this study, used only one competitive test so that the generality of the competitive order was not investigated as it was in the Baeninger study. Admittedly, however, partial support for her conclusions was obtained.

(c) Fowls : Douglis (1948) - Douglis was interested in the effects of changing flock membership on the peck order in fowls. Only overt aggressive responses were used as measures in this case, however, so that no test for unidimensionality was made.

(d) Fowls : Guhl (1953) - This is now one of the most frequently quoted references which, it is claimed, demonstrates that the peck order governs access to food in the domestic fowl. An examination of this study, though, reveals that it presents no data in support of such a claim. The only relevant relationship which is presented as a positive but nonsignificant

correlation during pen observations between social rank (the number of animals the fowl could peck) and the frequency of feeding during the daytime ($r = 0.15$) and a negative and nonsignificant correlation between social rank and the first animal to feed in the morning ($r = 0.03$). Guhl also pointed out that further work on such matters was required. He does, however, quote four references to demonstrate that dominance allows precedence to food. These were Masure and Allee (1934), Collias (1944), Guhl, Collias and Allee (1945) and Collias (1950). The Collias references were his reviews, which have already been discussed, as has the contribution of the third reference (Guhl, Collias and Allee, 1945) towards demonstrating priority of access to mating in dominant fowls. It is interesting to note that the only reference to priority in feeding in the Guhl et al study was also Masure and Allee (1934). Since neither of the Collias reviews mention a fowl study which demonstrates dominance-related priority of access to food, all Guhl's references seem to depend on the findings of Masure and Allee. But an analysis of this study reveals that the dominance order was measured in terms of aggressive behaviour only. The following statement is the sole observation by these authors as to the effects of the peck order on feeding behaviour. "When food was given W which stood lowest in the peck order never ventured near those cockerels which were eating but waited until they left the food and then ate what remained." The Guhl (1953) study can hardly claim, therefore, to have demonstrated the unidimensionality of dominance as Baeninger (1970) claims. However it must be noted in the case of fowls that Candland, Mathews and Taylor (1968) have since found a high relationship between the peck order and one measure of food competition.

(e) Fish : Braddock (1945, 1949) - Two studies by Braddock with fish use only the aggressive index of dominance, so that again no test was made for unidimensionality.

Thus it can be seen that not one of the references quoted by Baeninger (1970) provide a sufficient test to satisfy the conclusions that she makes for them, although partial support is obtained for her conclusions from the James (1951) paper.

III. Wood-Gush (1971)

The final example of the wide acceptance of the unidimensionality of dominance is provided by Wood-Gush (1971). This author, in describing the effects of the peck order on the social behaviour of fowls, states that "high ranking birds which deliver the most threats and win the most fights also have priority for food, nests, and roosting places and greater freedom of the pen." His references for this statement were Collias (1944), Guhl, Collias and Allee (1945) and Guhl (1953). All of these references have been previously discussed. The first review does not quote any relevant literature, while the second shows that dominance affects the mating behaviour of the sexes differentially, and the third, as already shown, provides no evidence for priority to food for the dominant animals, although there is some support provided for access to favoured roosting spots.

IV. Summary

In all, it can be seen that in the three publications examined the interpretation of the degree of support for unidimensionality of dominance by the authors is far too

definite in relation to the data provided by their quoted references. It almost seems as though their belief in the concept of dominance has prevented these authors from noticing that conflicting data exists, or alternatively has encouraged them to think that these exceptions to unidimensionality are rare and unimportant. The references which are continually quoted in these studies (for example, Masure and Allee, 1934; Collias, 1944; Guhl, Collias and Allee, 1945; Guhl, 1953) all seem to have gained an almost classical status as demonstrating the effects of a linear dominance order which is out of all proportion to the evidence they present. It would appear, therefore, that belief in the concept of an all-powerful dominance order has prevented a meaningful evaluation of the concept by most authors, even to the present day. In criticising the concept of dominance there is no need to doubt that the observational studies which have reported traditional dominance orders (Lockie, 1956; Coulson, 1968) in some animals have, in fact, been misleading. What is important to remember is that some studies, especially laboratory studies, have not found a correlation between aggressive and competitive orders and have sometimes reported low correlations between competitive orders. If this is the case all competitive measures of dominance must be methodologically validated and standardised competitive techniques devised. There is no longer any justification for regarding almost any competitive order as a manifestation of social dominance.

THE METHODOLOGICAL CONSEQUENCES OF THE LACK OF UNIDIMENSIONALITY

Having stated the need for such methodological precision it must be decided how this will be achieved and

what criteria will enable one to regard a competitive measure as a dominance index.

Firstly all competitive measures must be shown to have internal validity; that is, proof that they are adequate measures in terms of their particular response requirements, of priority of access of one animal over another. This would demand that competitive orders be related to individual skill at the competitive task in order to show that the competitive order is not just a mere reflection of this skill.

Secondly if internal validity is achieved the competitive order must be shown to have external validity. That is, it should be shown to relate to other social behaviours (for example, aggression) and it should also be shown that it is not response specific. This means that it must be shown to correlate highly with other internally valid competitive measures.

Internal validity and methodological considerations of the competitive test

Although the first requirement of internal validity seems simple enough to determine, the present lack of methodological and procedural agreement between many competitive tests creates problems for the assessment of the individual response requirements of any particular test. Lack of regard for the methodological aspects of competitive tests in the past has resulted in there being no classification of the different types of tests available and, what is more, disagreement in some cases on the variable which should be used to indicate competitive performance. As a result this discussion will centre on those methodological problems which

must be overcome before any serious attempts at internal validation can be made.

Most competitive tests can be classified into two main groups.

(1) The all-or-none competition : These are competitive tests in which two or more subjects are forced to compete for one discrete reward. This competitive situation is exemplified by those workers who have used the W.G.T.A. as a competitive apparatus. Here, for instance, the animals may compete, as in the Cole and Shafer (1966) study using cats, for one small piece of meat as a reward, or as in the Miller and Banks (1962) study where two monkeys competed for one raisin at a time. In this situation the animal gaining the most rewards is regarded as being the dominant. Another method which can be classified as an all-or-none competitive measure is the dominance tube (Schumsky and Jones, 1966) which is commonly used in studies of the competitive behaviour of rodents. In this apparatus one animal is required to push the other backwards down a narrow tube in order to gain a reward; again the animal gaining the most rewards is regarded as the dominant. As well as these two specific examples there are many other variations on this theme such as the perch tests recently devised by Clark and Nakashima (1972) or the shock avoidance measure of Hamilton (1960).

(2) The limited access situation : This type of competition restricts the reward source to a point location, but on this occasion the animals compete for control of the source for a specified time period. Usually the food or water reward is confined to a trough, or drinking tube in such a way that only

one animal can eat or drink at a time. A variation of this procedure is used by such authors as Bruce (1941) and Oldfield-Box (1969); this is to give two animals one food pellet and observe the time which each animal retains possession until it is finished. Here the animals controlling the reward source for the longest time periods are generally regarded as the more dominant animals, although sometimes the amount consumed is used as the competitive measure (James, 1949; Hoyenga and Rowe, 1969).

There are a number of general criticisms which can be made of both types of competition. The occurrence of a point source of food such as that in a limited access situation, for example, would be extremely rare in nature as would an all-or-none situation. But despite these limitations which may be inherent in laboratory methods, there are several methodological deficiencies which must be overcome before internal validation can be acheived for any particular measure.

1. Although there are two distinctive types of competition no comparison has been made between them as regards their differential effects on competitive behaviour or their relative theoretical utilities.

2. In the limited access situation there has been no decision as to whether the time spent in charge of the reward source or the amount consumed in competition is the more valid competitive measure. Hoyenga and Rowe (1969) have shown that there is a poor correlation between the two in rat competition.

3. Most studies define a "win" as being represented by the subject gaining more than its opponents of the competitive measure. Although this is convenient it must be established that this principle is suitable in the face of the knowledge

gained of expected variability of the competitive scores of the subjects according to their skill at the particular task and their individual fluctuations in performance.

4. Two accepted methods of assessing reliabilities of dominance relationships are now available. Firstly the outcome of every possible paired encounter can be established and the reliability of these assessed over a number of measures (for example, Brantas, 1968). The second method is to sum the number of wins or the raw competitive values over a completed round of competition and establish the degree of reliability by correlating these totals between rounds. This form of assessment of reliability is most commonly found in rat studies (for example, Becker and Flaherty, 1968) but it has also been used for other species such as domestic fowls (Candland, Mathews and Taylor, 1968). It is clear that the use of the first type of assessment makes more demands of the data than the second and it also meets the requirements of dominance theorists such as Bartos (1967) who maintain that there should be a dominance relationship between each animal in a group. Further work is therefore required in establishing which sort of reliability measure is appropriate and also to ensure that the second mode of analysis is not adopted merely because the data will not fit the first.

5. Many studies use a paired comparison technique of measuring competitive orders while some use whole group competitions. As yet there has been no systematic investigation as to which is the more useful procedure.

6. Finally, there are a series of smaller methodological problems and procedural differences which have, to this time, been ignored.

(a) Sometimes the loser is rewarded in all-or-none experiments, but sometimes it is not. For example Schumsky and Jones (1966) rewarded their losing animals whereas Work, Grossen and Rogers (1969) did not.

(b) Amounts of habituation to the competitive apparatus seem to be a matter of whim. For example Hoyenga and Lekan (1970) in a limited access apparatus, used one days habituation whereas Rosen (1964), also in a limited access situation, used ten days.

(c) The length of the competitive period in limited access measures of competition also seems to depend mostly on whim. For example, in the rat literature, the period varies from two minutes (Hoyenga and Rowe, 1969) to fifteen minutes (Ruskin and Corman, 1971) without justification from either paper.

(d) Deprivation levels in limited access studies also seem to differ from study to study, without comment. For example, the limited access literature using rats shows variation from conditions of five hours food deprivation (Baeninger, 1970) to seventy-two hours (Ruskin and Corman, 1971).

It would appear, therefore, from this long list of methodological deficiencies that much work is required before the standardisation of individual competitive tests will be achieved.

External validity or generality

As has already been noted there are two main types of external validity. The first is that it should be possible to generalise the competitive order to other observable social behaviours, and the second is that one must be able to

generalise from one internally valid competitive order to another.

1. Generality to other social behaviour

It is natural to assume that the social behaviour which should be related to the competitive order is aggression. In fact in the past this has been the usual method of validation of a competitive test, as Schjelderup-Ebbe's initial dominance orders were based on the observation of aggression. Traditionally those studies which show a correlation between the two orders have been interpreted as demonstrating an aggressive validation for the competitive measure. Those studies which have not shown such a correlation have, as a result, regarded the competitive order as an invalid measure of dominance. But in these cases the application of the concept of dominance to the aggressive order has seldom been questioned. However, since the currently accepted definition of dominance is "priority of access" it would seem that the prime purpose of a validation is to demonstrate such a priority.

The only possible way of "proving" priority from an aggressive order is to differentiate between a bulk aggression score and the number of group-mates which an animal can defeat (for example, Wood-Gush, 1957; Baeninger, 1966) and to regard the second measure as representing dominance. This does <u>not</u>, however, show that a unidimensional dominance order has been attained; only that there is an order of priority on the aggressive response. As with competitive orders, it should be shown to generalise to other priorities.

Even when the aggressive order does correlate highly with one competitive order this competitive order must be shown

to be internally and externally valid, so that at least two competitive orders are required as well as the aggressive order before it can be labelled with the global concept of dominance. The necessity for such a rigid criterion can be seen in the available literature from monkeys and rats (see Table 1.1). Although many studies report a high correlation between competitive and aggressive orders in monkeys Crawford (1942) and Bernstein (1969) found a low correlation between the normal aggressive order and performance in their competitive situations. The two relevant rat studies (Baeninger, 1970; Ruskin and Corman, 1971a) contradict each other as regards the relationship between aggression and food competition in this species. While Ruskin and Corman find a high correlation between aggression and competitive performance, Baeninger reports a low relationship. In general, therefore, it can be seen that when the emphasis on the interpretation of competitive orders changes to that of methodological validation the status of the aggressive order as the "true" measure of a global dominance is altered. An aggressive order becomes one of the two possible types of measures whose meaning is finally dependent on its relationship to the other priorities in a group. The interpretation of an aggressive order must be restricted to aggressive behaviour unless it can be correlated with a quantitative demonstration of a general priority of access.

2. Generalising from one internally valid competitive order to another

A second major outcome of this altered view of aggressive orders is that the interpretation that a low

correlation between aggressive and competitive orders automatically invalidates the competitive order as a measure of dominance may well have to be modified. If a highly generalisable series of internally valid competitive orders can be demonstrated in a group, the lack of correlation between these competitive orders and the aggressive order may well indicate that it is the interpretation of the aggressive rather than the competitive orders which will have to be altered. It must be remembered in these cases that it is impossible to obtain an external validation in aggressive terms for an aggressive order, so that there is no proof that this order is not a representation of individual skill at the aggressive response and as such is an inappropriate measure of social dominance. Thus it can be seen that, while a correlation between competitive and aggressive orders is desirable if a general dominance order is to be hypothesised, it is neither a necessary nor a complete validation.

The category of social behaviours to which a dominance order may relate is not exhausted by aggression. Crawford (1942), for instance, attempted to relate his competitive order in monkeys to other social behaviours such as social grooming, play, presenting and mounting; subsequent studies with different species have had similar aims (for example, Spigel, Trivett and Fraser, 1972; Long, 1972). But as with aggression this type of correlative analysis cannot provide direct validation for any measure of dominance although the data is of great interest once the validation has been achieved.

Another method of assessing the generality of the competitive order would be to measure social preference in a

competitive situation and, if possible, the same competitive situation as that in which the order was established. This procedure would, in effect, allow the subject to choose its competitors. If no social discrimination was observed in such a situation it could be concluded that the competitive measure did not affect social behaviour in the conditions in which it was measured and that the order could hardly be regarded as being a general measure of social dominance. If, however, choice behaviour was observed, the extent and nature of the effect of the competitive order could be assessed. For example, a procedure such as this could provide information about the relationship between social "distance" on the competitive order and the interaction between two animals as well as providing an analysis of the effects of consistent triadic dominance structures within a group.

This method could also provide a check on the internal validations of particular competitive orders; especially when the validity is difficult to assess because of the complex nature of the response requirements of the apparatus. For instance competitive procedures such as the dominance tube are generally validated in terms of a low correlation between running speed and competition only (Schumsky and Jones, 1966) when there are probably a diversity of responses relevant to competitive performance. The same may be said of the apparatus devised by Syme (1970) in which only a running speed validation was attempted. If a choice of competitor was provided for these subjects and preferences were observed in relation to the dominance order, this would lend support to the internal validation of the measure. It may be that our predicted results of an analysis of this

type are vastly over-simplified, but in the absence of any work of this nature it would seem that, regardless of the outcome of such studies, the results will be of great interest.

Between response validations

As can be seen from Table 1.2 too few studies have used more than one competitive test. Of those that have, however, there is a good proportion of low correlations between competitive measures, especially for rodents. Despite these low correlations no authors have as yet questioned the validity of applying the concept of dominance to their data. This is because most authors have either conducted their study in order to compare their dominance orders over differing rewards, or have used such widely disparate procedures and measures that they interpret their discrepancy in terms of the failings of one of their measures. An example of the first type of study is, of course, that of Baeninger (1970) who interpreted the low correlation which she found between food and water dominance orders to there being a different dominance order for the two rewards. Lindzey, Manosevitz and Winston (1966) provide an example of the second type of study in which they found a poor correlation in mice between performance in limited access food competition and in the dominance tube. Their interpretation was that it was possible that the dominance tube was an invalid measure of dominance in mice. It is clear from the previous discussion, though, that an equally plausible interpretation is that the so-called dominance orders merely lacked external validity, and that the competitive orders were response dependent.

It would appear, therefore, that there is an urgent

need for further studies to use a variety of competitive tests for each group of animals. These tests should be designed with systematic changes to the response requirements so that only a response interpretation is possible if a low correlation between tests is demonstrated. If a response interpretation can be used to explain the low correlations, the dominance hypothesis must be rejected as a consequence, since the response interpretation (that the order represents the differential skill of the subjects at the competitive task) is more parsimonious. However, if high correlations are found over a variety of internally valid competitive tasks, then and only then can social dominance be invoked to describe the competitive order.

This thesis examines the competitive orders of three species: the ferret, the laboratory rat, and the domestic fowl - in the light of the methodological guidelines set down in this introduction. It also aims to develop a situation as described above in which the subject has the opportunity to choose its competitors and thus examine the effects of the competitive order on social discrimination in a competitive apparatus.

The first study creates this condition for ferrets in the modified form of the dominance tube as devised by Syme (1970). In this way the only internal validation provided by Syme, that of a poor correlation between running speed and the competitive order, could be evaluated in the light of the ferrets' preference behaviour. The following studies are attempts to validate the competitive orders of both the laboratory rat and the domestic fowl in terms of the guidelines of this introduction.

TABLE 1.1

Correlations between aggressive and competitive orders. H represents a high correlation, the value of which exceeds 0.7. These are all statistically significant at the 5% level unless otherwise stated. L represents a low correlation, the value of which was less than 0.7.

Species	Author	Year	Correlation
Monkeys	Maslow and Flanzbaum	1936	H
	Crawford	1942	L
	Warren and Maroney	1958	H
	Mason	1961	H
	Bernstein	1969	L,H^{+}
	Christopher	1972	H
Dogs	James	1939	H
	James	1949	H
Cats	Winslow	1938	L
Rats	Baeninger	1970	L
	Ruskin and Corman	1971	H
Hamsters	Boice, Hughes and Cobb	1969	H
Fowls	Candland, Mathews and Taylor	1968	H
Frogs	Boice	1970	L
Fish	Noble and Borne	1938	H
Turtles	Evans	1940	H

+ : A high correlation for aggression in the usual group interactions but not in the apparatus.

TABLE 1.2

Correlations between competitive tests for those studies in which more than one measure has been used. H represents a high correlation, the value of which exceeds 0.7. These are all statistically significant at the 5% level unless otherwise stated. L represents a low correlation, the value of which was less than 0.7.

Species	Author	Year	Tests	Correlation
Monkey	Nowlis	1941	Food/Avoidance	H
	Hamilton	1960	Food/Avoidance	H
	Miller and Banks	1962	Food/Avoidance	H+
	Biernoff, Leary and Littman	1964	Food/Food	H
Cats	Winslow	1944a,b	Food/Food	L
	Cole and Shafer	1966	Food/Food	L
Rats	Bruce	1941	Food/Water	H
	Baeninger	1970	Food/Water	L
Mice	Lindzey, Manosevitz and Winston	1966	Food/Food	L
Gerbils	Boice, Hughes and Cobb	1969	Food/Water	L
	Wechkin and Reid	1970	Food/Shock	L
Hamsters	Boice, Hughes and Cobb	1969	Food/Water	H

+ : not significant

CHAPTER TWO

COMPETITIVE CHOICE IN THE NEW ZEALAND FERRET

C H A P T E R T W O

Introduction

Laboratory studies of aggressive (Poole, 1966, 1967, 1972) and competitive (Syme, 1970[1]) behaviour in ferrets, polecats, and ferret-polecat hybrids have failed to provide a clear analysis of the social organisation of these animals. Poole (1967, 1972) reports that, unlike many other species, the results of aggressive encounters in ferrets and polecats do not resolve themselves into definitive threat-submission relationships. Syme (1970) established competitive orders in ferrets using both a grouped and paired comparison situation, yet concludes that "their full social interpretation awaits further investigation."

The purpose of the present study was to relate the order obtained in ferrets, using a paired comparison competitive procedure, to other social behaviours in this species. This way both the validity and utility of the method, as a social measure, could be explored. Experiment 1 investigates social preference. If the competitive order does, in fact, have general social implications one would expect that, when allowed to choose their competitor in a competitive situation, the ferrets would choose against the competitive rank order, especially if this order was representative of social dominance. Social preference in a noncompetitive situation is also examined.

1. For a description of this study see Appendix 1.

Experiment 1

Subjects

The Ss were 5 male and 5 female ferrets selected from a colony maintained by the Psychology Department at the University of Canterbury. The animals were caged in two single-sex groups of 5 in pens measuring 1.0 x 1.0 x 2.6 m for a month before experimentation began. The ferrets were 4 months old at the beginning of the experiment.

Apparatus

Competitive 1. This apparatus was designed to measure a paired comparison competitive order in ferrets and is described in detail by Syme (1970). The apparatus consisted of a start box which led, by means of a guillotine door, to a larger area, the "decision space" which, in turn, led to a narrow pipe (diameter: 9.2 cm for males, 7.2 cm for females) which was wide enough to allow one ferret to pass comfortably but not two. The body of the apparatus was constructed of wood painted with a white semi-gloss, while the lids and roof were made of perspex to permit observation of Ss. The dimensions of the apparatus are shown by the scale in Fig. 2.1.

Competitive 2. This apparatus was essentially a double dominance tube constructed in such a way that S, or choosing animal, could enter one of two competitive start boxes depending on its choice of competitor. A diagrammatic representation of this apparatus may be seen in Fig. 2.2. As for the single apparatus, the sides and floor of the apparatus were constructed of wood and painted with a white semi-gloss. The roof and lids were made of either steel mesh

or perspex so that behaviour within the apparatus could be easily observed. The boundary between the choice box and the two start boxes was covered with a strong, wide-gauge steel mesh. Inset into this were two 13.5 x 11.5 cm one-way perspex doors which enabled the Ss placed in the choice box to enter either start box. These doors were hinged at the top and prevented from swinging back into the choice box by a slightly raised step (1.3 cm above floor level) fastened to the floor on the choice-box side. Further security that the door would open one way only was provided by a 2.5 cm wide protective archway on the start-box side of the doors. This prevented the ferrets from scratching sideways at the bottom of the doors and crawling through them when they were levered open. The steel mesh frame and perspex doors enabled the ferrets in the choice box to maintain both visual and olfactory contact with the stimulus animals.

Both start boxes led to decision spaces via guillotine doors. In contrast to the individual apparatus, where these doors were constructed from 0.6 cm hardboard, on this occasion heavy 2.3 cm thick pieces of wood were used. For the double apparatus these doors could be locked from above by rotating a large cup hook which was attached to the roof. The need for a heavy door and lock in the choice apparatus was created by the activity of the stimulus animals which, having to wait for release over relatively long periods, soon learnt to open this type of door. Decision spaces were identical for both sides of the apparatus, as were the competition pipes.

Noncompetitive choice. This apparatus was designed to measure social preferences in ferrets outside the competitive situation. It was a T maze in form with equal arms 1.13 m long and

0.17 m wide. At the end of each goal arm was a 0.45 x 0.17 m holding box in which the stimulus animals were confined. Again a thick steel mesh separated the stimulus ferrets from S, this enabling the S to maintain visual and olfactory contact with the confined animals. The apparatus was constructed of steel and the interior was painted light grey. The wire mesh roof allowed observation of behaviour within the apparatus under normal room illumination. Time spent in the three arms of the "maze" was obtained using three telegraph keys linked to an Esterline Angus recorder.

Procedure

Part 1. Paired Comparison Competition

Each animal was trained individually to run through the apparatus for 10 trials per day. The reward for each trial was a small piece of meat (about 2.5 g) and the animal was not fed in the home cage. Milk was given as a dietary supplement each day after testing; about 0.4 litres being provided for each group. This practice was continued for 11 days for the 5 males, after which the average time per trial for each animal was 3.5 sec or less. It took the females 14 days to reach the same criterion.

All males then competed with every other male twice for 10 trials during two randomly chosen paired comparison rounds of competition. Two pairs of ferrets competed each day, while the remaining animal was run alone, to ensure that every S obtained 10 rewards from the apparatus per day. The ferret emerging first from the pipe was regarded as being the winner or "dominant" animal for the trial. Using this method it took 5 days to complete each full paired-comparison round. Exactly the same procedure was followed for the females.

Part 2. Choice for Competition

Immediately following the final day of paired comparison competition the animals began training in the choice dominance tube for 10 trials per day. These trials began with the animals being placed in the choice box and run through either start box for a reward, which was again about 2.5 g of meat. The side through which the animals were directed was governed by locking one of the guillotine doors. This was done with a bolt positioned in a hole in the floor in such a way that, although it blocked the movement of the door, it was hidden from view of the ferret by the step in the choice box. The Gellermann (1933) series of stimulus sequences was used to decide the order of the sides through which the ferrets were guided. This was to avoid the emergence in any individual of a side, or alternation preference. Training was continued for 5 days for both sexes.

Competitive trials followed the habituation period. The S was placed in the choice box and allowed to choose its competitor from two stimulus animals; one in each start box. When S entered either start box the competitive trials were run as in Part 1. Thus both male and female Ss were provided with a choice between every possible paired combination of the remaining animals in the group. Each ferret was presented with its pairs in a random order, while the S order was arranged to ensure that each animal was tested in this capacity every fifth day. For each of these choices S was presented with the stimulus pairs on 20 consecutive trials. When S had chosen its competitor and the outcome of the competition had been established the animal which had not competed was run through the apparatus and duly rewarded. Both stimulus animals were

then replaced in the start boxes, with the sides in which they were replaced being decided by the Gellermann series. The S was then replaced in the centre of the choice box. Since only 3 of the 5 animals could be tested each day the remaining 2 were run alone through the apparatus for 20 trials according to the Gellermann series.

Part 3. Noncompetitive choice

A noncompetitive social preference experiment was carried out at the same time as the competitive choice study. Observations for these measures were obtained approximately 4 h after competitive testing. Before the social observations were made each ferret was habituated to the apparatus, alone, for 10 min per day for 10 days. When measurements began the stimulus animals were placed in the holding boxes and the chooser was introduced to the unoccupied arm of the T maze. For 7 min the location of S was recorded continuously. A "preference" for a stimulus animal was defined as the S having its front feet in the same alleyway as the caged stimulus animal. The total time spent in each alleyway was recorded.

One trial was run daily for both males and females, with the choices available to each animal being randomized but with each ferret acting as S every fifth day. Because of the possibility of side preferences, each stimulus pair was presented twice with the sides reversed for the second measure. As far as possible each animal appeared equally often in both holding arms in the first round. The order for the second round was again chosen randomly.

Part 4. Paired Comparison Competition

A final round of paired comparison competition was

conducted for both sexes with 20 competitions being held between each pair on the same day.

Results

The reliabilities of the paired comparison competitions for both sexes are shown in Table 2.1. Coefficients of agreement between the second and third rounds of competition proved to be significant for both sexes which demonstrates the reliability of these orders over the time period in which the competitive social discrimination trials were carried out. These orders may be seen in Table 2.2. As indicated by the Landau coefficients (Landau, 1951) all hierarchies approximated linearity and, although the second order in the males had two transitive relationships, this had changed to a perfect hierarchy by the third round.

The competitive orders were then analysed using a length of longest run test with known probabilities (in this case $p = 0.5$) and this resulted in 7 consecutive choices out of the possible 20 being regarded as significant ($p = 0.04$). Using this criterion only one significant choice was observed for the males; for this choice the less "dominant" animal was chosen on all 20 trials. For the females 3 choices were observed, 2 of which were made by the same animal and were directed against the alpha animal and the third made by the alpha animal but in this case towards the more dominant ferret. Side preferences were often observed in the remaining discriminations and these proved to be significant on 26 occasions. No other consistent response pattern emerged.

Tables 2.3 and 2.4 show the ratio of wins to competitive encounters for each S (1) in the paired comparison

competition, (2) when acting as S in the choice apparatus, and (3) when competing as a stimulus animal. While there is a high Spearman rank correlation value between the rank ordering of the subject and stimulus columns ($r = +1.0$, $p = 0.01$) for the males, this relationship was not as high for the females ($r = +0.67$, $p > 0.05$). A Wilcoxon matched pair signed ranks test was also calculated between the wins per competition measure in the subject and stimulus columns, revealing a significant decrease in the ratios from the subject to the stimulus condition ($d = 3$, $p < 0.01$). Thus the ferrets performed better in competition when allowed to choose their competitors than when they were chosen.

For the noncompetitive social choices the total amount of time spent in the non-social arm was calculated for each S. A comparison between the totals obtained by males and females was made and a Mann-Whitney U test revealed that the females spent significantly less time in the unoccupied arm ($U = 1.0$, $p < 0.02$).

A preference for a stimulus animal on any one trial was defined in terms of S spending more than 50% of its "social" time in the same maze arm as that animal. These preferences were analysed in two ways. Firstly a paired comparison matrix was constructed from the preferences of each animal on both rounds. Then a Coefficient of agreement was calculated between the two matrices obtained for each S. None of the resultant values proved to be significant, although it must be remembered that all 6 choices had to be consistent before a significant value could be obtained. Secondly the results were analysed in terms of the consistency of preference shown by each S for each of its groupmates. During the two completed paired comparison

rounds of choice each animal was confronted with each of its groupmates, as a stimulus, six times. A perfect choice for or against any animal during these six trials, using a Sign test, represented a significant preference or aversion ($p = 0.02$). However this happened on one occasion only. Since there were 40 choice situations in all for the analysis, this single significant choice could well have been a chance occurence. Thus the noncompetitive social preferences were neither reliable from round to round nor generally consistent for particular subject-stimulus pairs. This was further demonstrated when the proportions of time spent with each other ferret were averaged over the 6 presentations for each S. The results for both sexes can be seen in Tables 2.5 and 2.6. Only two values from either Table (these being for a single male) fall outside the 40 - 60% range which, in view of the small number of observations, would seem to indicate a general lack of discrimination.

Discussion

The few positive results obtained in the competitive social discriminations suggest that the paired comparison order did not affect choice in the competitive situation. This would seem to invalidate the competitive order as a measure of dominance since it could not be shown to relate to social behaviour in the environment in which it was established. However the possibility remains that this was due to methodological deficiencies in the experiment rather than the lack of social significance of the competitive order. There were four conceivable limitations in the competitive procedure. Firstly the number of trials allowed for choice could have been insufficient for the animals to discriminate between competitors.

This criticism would seem to be supported by Pollard et al (1967) who, when demonstrating visual discrimination in ferrets, recorded no improvement after 182 trials in an upright vs. inverted triangle discrimination but after reverting to a simple black-white discrimination for a further 104 trials found that the triangles were rapidly discriminated. This improvement was interpreted in terms of the development of a learning set during the black-white discriminations. It appears likely that such a set was not established in the present experiment because of the small number of discrimination trials presented, the difficulty of the initial problem, or a combination of these two factors.

A second criticism concerns the assumption implicit in the present study; that ferrets will tend to avoid competition. This assumption was tested in a complex relative condition before it was established absolutely in an experiment in which a choice could be made between a competitive or noncompetitive state. Since the losing ferret was rewarded soon after emerging from the pipe regardless of its performance a third criticism may be that, although the apparatus can logically claim to be measuring "priority of access" as required by van Kreveld's (1970) definition of dominance, the difference between win and loss was not marked enough to encourage choice behaviour. A final possibility is that the barrier between the choice and start boxes did not allow the ferrets to make individual discriminations. In this respect, however, it must be remembered that for one male choice the same animal was chosen on all 20 trials - an event of very low probability ($p < 0.001$).

The significantly greater proportion of wins per competitive trial obtained by the ferrets when acting as

subjects in the choice experiment is interesting but hard to explain. If social preferences against competitive dominance were consistently observed this relationship would have been expected. However, in the absence of such choices one must conclude that the subjects did better against the same opponents when they moved into the start box from the choice position. It must be realised, though, that in spite of the differences between the subject and stimulus conditions being consistent they are still quite small. In some cases the subject ratios were less than those obtained in the ordinary paired comparison condition so that no universal gain was acquired from the opportunity to compete. Further interpretation of the phenomenon will have to be made from evidence gathered while investigating the aforesaid limitations of the present study.

In finding no evidence for noncompetitive social choice in ferrets the present study provides a contrast to the results obtained by Nowlis (1941) who demonstrated marked and consistent social preferences within a group of five chimpanzees in an apparatus comparable to the one employed in this study. Murchison (1935b) also found preferences which, in this case, were related to dominance. Caged stimulus animals were used within a small group of chickens. However it should be noted that the same result was not obtained under the same experimental conditions by Guhl (1942) who used mature birds and found little evidence for any discriminations under these conditions.

This variability in the ability to discriminate between individuals could reflect differences in the social capacities of ferrets, monkeys and fowls; or could be explained by the limitations of the practice of caging stimulus animals,

a procedure which was followed in all four studies. As Latanê (1969) and Guhl (1941) point out, the caging of stimulus animals in social preference tests has two major disadvantages. Firstly it can significantly alter the normal behaviour of these stimulus animals, and secondly in the absence of direct social contact between the subject and stimulus animals there seems little reason for the subject to be motivated to make a discrimination.

The shorter time periods spent by the females in the non-social condition represents a greater tendency on their behalf to be found in the presence of other ferrets than males. This may be indicative of sex differences in the natural social organisation of these animals, but as for the social times, it could also be an artifact of the experimental apparatus.

Experiment 2

Introduction

This experiment was conducted primarily to investigate the main criticisms of the procedures used for the measurement of competitive and noncompetitive social choice in Experiment 1.

In the first part of Experiment 2 the effect of providing a large number of discrimination trials is investigated by presenting the same animal with two choices for a large number of consecutive trials over alternate days. Part B satisfies the criticism that a direct test of the ferrets' preference for or against competition has not been made, by providing the subjects with a choice between an occupied and an unoccupied dominance tube. In the third part of Experiment 2 the question that there may not have been a sufficient

delineation of outcome in the first experiment to motivate the animal to choose, is investigated by dispensing differential reinforcement for responses to the various stimulus animals. This procedure also had the advantage that it could provide more conclusive evidence as to the ease with which ferrets can make individual recognitions under experimental conditions.

Finally, an attempt is made to repeat the noncompetitive social choices in an unrestricted environment in order to overcome the problems of caging stimulus animals.

Part 1. Long-term choice

Subjects and Apparatus

The ferrets used were the 5 males previously employed in Experiment 1. Maintenance conditions were identical to those operating in the first experiment.

Procedure

The male S which was ranked third in the linear hierarchy was chosen as a S for this investigation. No previous social preferences had been recorded for this animal. In selecting this ferret it was possible to choose, from the 4 remaining animals in the group, 2 pairs of stimulus ferrets which differed in relative "social distance" as measured by the competitive order. The pairings of these animals were the top and bottom (M1 and M5) and second and fourth (M2 and M4) ferrets of the competitive order.

The competitive choices for this experiment were conducted in exactly the same way as Experiment 1, except on this occasion there was only one subject, M3. Each day for

14 days this animal was presented with either a M2/M4 or an M3/M5 ferret choice for 20 trials. The side on which each stimulus animal was presented during these trials was varied according to the Gellermann series and all animals were released and rewarded on every trial. For the first 12 days the M2/M4 and M1/M5 choices were alternated from day to day. However on the thirteenth and fourteenth days the M1/M5 choice was presented consecutively owing to a minor illness of subject M4.

Part 2. Ferret-no ferret choice

Subjects and Apparatus

These were the same as in Part 1, except that the female ferrets used in Experiment 1 were reintroduced to the study. As with the males they were maintained under the same conditions as for the first experiment.

Procedure

As in Part 1 this was a simple choice experiment in the double dominance tube only on this occasion the S, when placed in the choice box, was confronted with only one stimulus animal vs. a vacant start box. Twenty trials per session were run using this choice. The S animal was placed in the choice box and if it entered the start box which was unoccupied, it was allowed to run immediately for a meat reward. It was then placed in a holding cage while the stimulus animal was released, rewarded, and replaced in a start box in readiness for another trial. The side to which the stimulus animal was returned was governed by the Gellermann series of stimulus sequences. If S chose the occupied start box the competition was conducted

in the normal manner and the stimulus animal replaced as above.

Using this procedure each animal was provided with a choice between every other animal in its group, and an empty dominance tube. Since two such choices could be run each day for each group and there were a total of twenty possible combinations, this part of the experiment took 10 days to complete. The order of presentation of stimulus animals was randomised for each S. Every day the animal which was not involved in the choice experiment was run through the apparatus alone and directed according to the Gellermann series, for 20 rewarded trials.

Part 2 was conducted immediately after Part 1 for the males and the first experiment for the females, so that no initial retraining to the apparatus was required.

Part 3. Differential reinforcement

Subjects and Apparatus

The Ss for this experiment were 4 naive male ferrets about 7 months old at the beginning of the experiment. They were housed in a pen measuring 1.0 x 1.0 x 2.6 m. Throughout the experiment ad lib. water was provided but all food was restricted to the experimental setting. A small volume of milk was given daily as a dietary supplement. Both single and double dominance tubes were used in this investigation.

Procedure

The ferrets were trained to run through the single dominance tube for 10 trials per day for 12 days, after which all animals had an average time per trial of 2 sec or less.

Differentially rewarded trials then began. For these, 2 animals were reinforced in the presence of 2 group members in the single dominance tube regardless of their competitive performance, but they were never reinforced in competition with the remaining group member. The remaining animals were reinforced in competition with only one animal, and they were never reinforced with the other two. In this way an artificial reward order was established in the single dominance tube. A representation of this order may be seen in Fig. 2.3. This procedure was carried out on a paired-comparison basis for 10 trials per day until 230 trials had been run for each pair. After each pair of animals had been run each day the non-rewarded animal was returned to the apparatus alone for 10 rewarded trials. The order for the first paired comparison round was chosen randomly, but thereafter the same order was repeated from round to round. The number of training trials using this procedure was comparable to that used by Pollard et al (1967) for visual discrimination.

After the animals had been habituated to the dominance tube for 20 trials on two consecutive days, choice testing commenced. In general terms these choice trials were run along the same lines as those of Experiment 1, with each ferret choosing between each possible pair of the remaining group members. During the choice phase the differential reinforcement was continued in the resulting competitive trials. If, as a result of this, the subject animal or either of the stimulus animals did not gain at least 10 rewards from the apparatus they were run alone, to bring their total number of reinforcements for the day to this level. The fourth animal, which was not involved in the choice experiment on any particular day, was

run for 20 rewards individually in the dominance tube with the sides being alternated in accordance with the Gellerman series.

Part 4. Noncompetitive Preference

Subjects and Apparatus

The Ss were 5 male and 5 female ferrets aged 4 months at the beginning of the experiment and caged in single-sex groups in separate pens measuring 1.0 x 1.0 x 2.6 m. Both groups were provided with ad lib. food or water throughout the experiment.

The apparatus was a 2.0 x 2.0 x 0.3 m high arena with a wire mesh lid and a heavy translucent glass floor which was raised so that illumination could be provided from below by four 40 W fluorescent tubes. A series of black lines divided the floor space into 0.3 x 0.3 m squares. During experimental observations the rest of the room was maintained in darkness. An auditory time sampler was used to regulate behavioural observations.

Procedure

The procedure adopted was a modified form of that developed by Latané (1969) for rats, in which sociability was measured in terms of the time spent in bodily contact and the distance between two unrestrained rats in an open field. On this occasion, however, the analysis was to be restricted to the first measure. This limitation was imposed owing to the conceptual difficulties which Latané, himself, has come to acknowledge with the interpretation of social distances (Latané et al, 1972). After habituation to the apparatus for

10 min periods over 10 days the ferrets were placed in the enclosure singly for 7 min, and their location in the apparatus was recorded every 10 sec. On the following day a series of observations began, in which the ferrets were placed in the enclosure in threes, and the social state of the group recorded on a 10 sec time sample basis over a 7 min period. Using this procedure there were 5 possible social conditions for the three animals:

S1 - A and B and C in contact,

S2 - A and B in contact and C alone,

S3 - A and C in contact and B alone,

S4 - B and C in contact and A alone,

S5 - A and B and C alone.

To facilitate recognition of the ferrets by the observer each was marked with bright coloured tape attached near the base of the tail. Only one of the 10 possible triads was run per day for each group, in order to ensure that no ferret appeared twice in the apparatus on the same day. The order of presentation of triads was chosen on a random basis, although efforts were made to ensure that each ferret appeared at least once every 2 days.

Results

Part 1. Long-term choice

The choices made by subject M3 may be seen in Figs. 2.3 and 2.4. For that between M1 and M5 there was a moderate tendency to prefer M5. If the choice is analysed in terms of the separate days' results, again with a length of longest runs test with known probabilities ($p = 0.5$) a significant preference is observed on Days 4 and 5 only.

For the M2/M4 choice a more marked tendency to choose against the competitive order is shown. But again, if these results are analysed day by day significant preferences emerge only on Days 2,3 and 4. It is interesting to note that the days on which preferences were observed in both choices were not the last in the series.

Part 2. Ferret - no ferret choice

The numbers of significant choices for the occupied and unoccupied dominance tubes as well as the nonsignificant occasions for both males and females are shown in Tables 2.7 and 2.8. A significant choice was again defined as 7 or more consecutive responses to the same stimulus animal. There were no significant choices for the occupied competitive tube, whereas there were 10 significant choices for the unoccupied tube for the males and 2 for the females. Using the Binomial test this represents a significant between-sex difference ($p = 0.38$, two-tailed).

An important aspect of the data is the number of nonsignificant discriminations, which accounted for 70% of the data. On 18 of the total of 40 discriminations significant side preferences were observed.

Part 3. Differential reinforcement

By the end of the last paired comparison round of the single dominance tube training trials the average number of wins per 10 trials of the non-reinforced animal was 1.1.

For the choice part of the study, on 8 of the total of 12 choice presentations the S was provided with a choice between an animal with which it was always reinforced and an

animal with which it was never reinforced. No significant preferences (a run of 7 choices or more) were, however, observed under these conditions.

Of the remaining 4 presentations, on 2 occasions the S was presented with 2 reinforcing animals whilst on the other 2 it was presented with 2 non-reinforcing animals. Again no significant social preferences were observed. One of the double non-reinforcing occasions had to be terminated, however, since the animal refused to leave the choice box after 8 trials.

Table 2.9 shows the number of times the chooser emerged from the competition pipe first, or "won" the encounter, when it chose a reinforcing or non-reinforcing ferret. It can be seen that, even after 230 training trials, the chooser "won" a relatively high proportion of trials in which a non-reinforcing animal was chosen. This would seem to indicate that, even when the subject and stimulus animals were in physical contact, the previous training trials had little differential effect on running behaviour in the dominance tube.

It may be noted that, in this experiment, especially in the training trials, non-reward was frequently accompanied by aggressive behaviour directed against the experimenter, attempts to block the reinforced animal from running through the tube, or, particularly in the single dominance tube, a refusal to leave the start box after the first few trials.

Part 4. Noncompetitive preference

Analysis of the social groupings of the triads was carried out on a sequential basis similar to that adopted in the competitive social choice situation. On this occasion, since two of the five possible social states (S1, S5) could

not provide discrimination between the behaviour of the three animals, only the paired conditions (S2, S3, S4) were subjected to the analysis. Thus for each of the 10 male and 10 female triads the sequence could be as long as 42 or as short as 0. These sequences were then analysed in terms of the length of longest run with known probabilities, with the probability of each state being regarded as ⅓ (Bradley, 1968). Implicit in the assumption that each social pairing was equiprobable was the premise that the social contact frequency of any one pair was not unduly weighted by the overlapping spatial preferences of the two Ss involved.

To ensure that there were no spatial preferences of this nature the individual data collected for both males and females was matched, observation by observation, over the 7 min to form 10 artificial triads for each sex. These were then analysed in the same way as the triads in the social condition. For this analysis the physical contact social condition was defined as being represented by an animal being found in the same square as another animal at the same point in the 7-min time sequence. No significant spatial sequences of pairs were, however, observed, with the longest run being only 2 and the highest whole sequence being only 5. There were no coincidental triples (S1) observed. The assumption that no social contacts between these ferrets were biased by spatial preferences thus appeared to be reasonable.

Using the length of longest run test in the analysis of the social triads, one significant sequence ($p < 0.05$) was obtained from the 10 male triads whereas 5 significant sequences ($p < 0.001$) were obtained for the females. These significant values demonstrate that, of the number of occasions on which a

pair of ferrets were observed in physical contact in a particular triad, one of the three possible pairs was found together on more consecutive occasions than would be expected by chance. Details of these sequences are shown in Table 2.10.

Tables 2.11 and 2.12 show the number of times each ferret was found in contact with each of its group members, and these values include the five triple observations (S1) for the males and the four observed for the females. These Tables also show the number of significant sequences in which each S was involved. It is immediately obvious that the variability of the total sociability scores for the females (Coefficient of variation, V = 0.45) is far greater than that for the males (V = 0.10). A Mann-Whitney U test showed a nonsignificant difference between the total sociability scores for the two sexes ($U = 5$, $p < 0.05$). This contrasts with the value obtained in the T maze test, where the females proved to have significantly lower times in the non-social arm than did the males. But it is interesting to note that the grand total sociability score for the females in this second experiment is more than twice that for the males.

Another interesting aspect of the females' data is that, if a rank ordering is made of the number of significant sequences in which each ferret was involved and it is correlated with the rank ordering of the total sociability scores for the same animals, a perfect value is obtained ($r = 1$, $p = 0.01$). This seems to indicate that significant sociability pairings are the result of a general tendency to be sociable, rather than from a specific social preference. This conclusion is supported by the fact that the two most sociable females were found together twice in a significant pairing.

Discussion

The results for Part 1 suggest that, had more discrimination trials been allowed in Experiment 1, more competitive preferences would have been observed. Significant choices for the more "submissive" animal were observed on five separate days under the extended condition. But perhaps the most interesting outcome of the extended trials was the lack of choice shown by the subject animal on the last two or three days discrimination for each stimulus pair. This would seem to suggest that, even though the subject was capable of making a discrimination on these later trials, the competitive order was not a significant determinant of behaviour at this time.

The second part of Experiment 2 proved to be more productive in terms of results than did the between-ferret choices in the first study, at least for the males. On half of the twenty discrimination trials the males chose the unoccupied dominance tube, whereas the females produced only two choices of a similar nature. No preferences were observed by either sex for the occupied tube. For the males this demonstrates a tendency to avoid competition but, as for the results of Part 1 of this experiment, this trend was by no means complete or continuous. The number of significant preferences in the first ten discriminations (4) did not differ markedly from that of the second ten (6) so that the small proportion of preferences cannot be interpreted as showing the development of a learning set in the later choices for each ferret.

While explaining the sex difference in the performance of the animals during the ferret-no ferret discrimination it is tempting to invoke a social explanation, but an equally

plausible interpretation, in terms of other motivational variables, is possible. Since the females were much smaller than the males and they were maintained under identical deprivation conditions throughout the experiment it seems reasonable to suppose that they were less motivated than the males in the experimental setting. The behavioural consequences of this difference in motivation could well be the fewer choices shown by the females. A social interpretation could, perhaps, be that since the females are more sociable than the males in the T maze they were also more sociable in the competition apparatus. Thus the disadvantages of competition did not outweigh the advantages of sociability. A further possibility is that an interaction between the social and motivational factors caused the lack of discrimination exhibited by the females.

The emphasis in Part 3 was on creating a larger difference between reward outcomes for the discrimination of certain group members than was obtained in the competitive discriminations of Experiment 1. However, unlike the first two manipulations of the original experimental procedure, this produced no increase in the number of discriminations observed. In fact, after 230 training trials of all-or-none reinforcement in the single dominance tube and 20 trials with the reinforcement differential maintained in the double apparatus, no preferences were recorded for the rewarding outcomes. It was also noted in the double apparatus that the competitive performance of the non-rewarded subjects was maintained to a larger extent than in the single tube. This could be because in the double dominance tube the subject was reinforced on a variable ratio basis as contrasted with the continuous reinforcement or extinction operating in the single apparatus. The lack of social choice on this occasion probably indicates the failure

of the ferrets to generalise from the single to the double apparatus.

Thus we may conclude that both Parts 1 and 2 of this experiment justify the previous criticisms made of the procedure in Experiment 1, if only for the male ferrets. A greater degree of social differentiation was observed in these phases of the second experiment than in the first. From Part 1 it appears that, if more discrimination trials had been allowed in Experiment 1, more preferences might have been observed. Part 2 suggests that on a simpler choice problem than that presented in Experiment 1 male ferrets perform much better. This could indicate that, as in the visual discrimination problems of Pollard et al (1967), if this simple discrimination had been presented before the more difficult between-ferret trials a learning set may have been established which could have markedly improved choice performance. However this proposal should be accepted with caution; the ferrets used in this experiment were the same as those used in Experiment 1, so that the number-of-trials variable has been confounded with the ease of the discrimination task.

Part 3 provides a further possible criticism of the procedure of Experiment 1 in that there may have been a failure to generalise from the single to the double dominance tube. This would suggest that it may have been better either to use the double dominance tube to establish the original dominance hierarchy, or to have provided some behavioural "bridge" between the single and double dominance tubes by utilising something like the ferret-no ferret choice. If the first tactic had been chosen, however, there would still have been no choices presented to the ferrets during the establishment of the competitive

hierarchy, so that the advantage of such an action for the subsequent choices would be limited. Thus the second method would have been preferable in that a learning set could have been established before the choices were presented. A combination of these two methods could, of course, be adopted.

So far the criticisms of the experimental evidence obtained has centred around the methodological limitations of the experiment. However an equally plausible line of argument can be traced from the competitive order itself. If, to enable the demonstration of the social significance of the competitive order, the methodological requirements are as stringent as those required to demonstrate a visual discrimination in what is a primarily non-visual animal (Pollard and Lewis, 1969), the importance of this order must be extremely limited. And if, as is suggested by the results of Part 3, there is a failure to generalise from the single to the double dominance tube, the social applicability of orders measured in the single apparatus are similarly limited. It would, therefore, be of interest to compare the influence of the competitive order on social choice with other overt social behaviours such as aggression. However, if after the appropriate methodological refinements have been completed, consistent choices are observed away from the competitive order, then it may have some importance at least in the social organisation of the ferret in the laboratory.

The sociability results of Part 4 are among the most interesting so far obtained in these experiments. A clear sex difference emerged from the sociability measure. Although this sociability may well be apparatus specific, the fact that the ferrets could interact freely gives far more hope than other

experiments in this series that the findings can be generalised to the natural organisation of this species. Unfortunately there is little detailed behavioural knowledge as yet available from field studies, although some descriptions of the general ecology of these animals in New Zealand has been obtained by such workers as Marshall (1963), Fitzgerald (1964) and Lavers (1972). Thus it would appear that psychologists interested in ferrets, rather than competitive orders, would be more gainfully employed in the field at the present time.

Experiment 3

Introduction

This experiment was conducted as a further attempt to relate the paired comparison competitive order to choice behaviour in the double dominance tube. It was also designed as a second attempt to relate an artificial reward hierarchy to subsequent choice behaviour.

Part 1 consisted of what was essentially a replication of the experimental design of the first experiment, except that on this occasion after eighty trials of competition with each groupmate, a series of ferret-no ferret choices were run in the hope of providing a learning set for subsequent choice trials.

Part 2 was a replication of Part 4 of Experiment 2, but again a series of ferret-no ferret choices were provided in order to create a learning set before the between-ferret choice trials.

Part 1

Subjects and Apparatus

The Ss were 5 male ferrets about 4.5 months old at the beginning of the experiment. They were housed and maintained under identical conditions to those for the Ss in Experiment 1. Both the single and double dominance tubes were used for the present study.

Procedure

After 8 days habituation of 10 individual rewarded trials per day the maximum time per trial was 2.2 sec. Competitive testing then began. Four paired comparison rounds of competition were conducted for 20 trials per competitive pair in the same manner as Experiment 1. Two days of habituation were then allowed for the double dominance tube. A series of ferret-no ferret choices were then conducted for 20 trials per choice in the same manner as Part 2 of the second experiment. Finally, between-ferret competitive choices were conducted in the same manner as Experiment 1.

Part 2

Subjects and Apparatus

The Ss were 4 male ferrets about 4.5 months old at the beginning of the experiment. They were caged in the same pen as the animals in Part 3 of Experiment 2 and were maintained under the same conditions as these animals. Both single and double dominance tubes were used in this study.

Procedure

The animals were habituated to the single dominance tube individually for 10 rewarded trials for 10 days. By this time the average time per trial for each animal was 2 sec or less. The procedure was the same as that in Part 3 of Experiment 2 except that between the 230 differentially rewarded trials for each pair and the between-ferret choice trials 40 ferret-no ferret choices were allowed for all possible subject-stimulus combinations. These choices were run in two randomly ordered separate rounds of 20 trials each, both of which were conducted in exactly the same manner as that employed in Part 2 of the second experiment. In the between-ferret choices of the present experiment there were 3 completed rounds with 20 trials for each discrimination, giving a total of 60 trials in all for each discrimination. The order of the first round was chosen as for the equivalent trials in Experiment 2, and this order was repeated for the second and third rounds.

Results

Part 1

Table 2.13 demonstrates the perfect linear hierarchy which was obtained in the group during the third and fourth rounds of competition trials. For the competitive-noncompetitive choices only 3 significant preferences out of a possible 20 were observed. All of these were against the competitive order. A significant preference was again defined as 7 or more consecutive choices to the same stimulus.

Only one significant ferret preference was observed in the between-ferret choices. This was against the competitive

order. On 17 of the remaining trials significant side preferences were observed. The wins per competitive trial ratio was calculated for each S when (1) in paired comparison competition, (2) acting as the subject animal, and (3) acting as a stimulus animal. These values may be seen in Table 2.14.

Part 2

A diagrammatic representation of the reward hierarchy may be seen in Fig. 2.5. By the end of the last paired comparison round of single dominance tube training the average number of wins per 10 trials of the non-reinforced S was 0.9.

Two significant choices were observed during the 24 ferret-no ferret choices. Both of these were made by the same S away from the same stimulus animal on the first and second round of choice.

In the three rounds of competition 4 preferences against the non-rewarding animal were observed with none against a rewarding stimulus animal. Three of these preferences represented the same choice as that in the ferret-no ferret trials and were made by the same S for the same stimulus pair on all three rounds. The fourth choice which was made in the second round was made against a non-rewarding animal. During the choice trials the average wins per 10 trials of the non-rewarded Ss was 3.2.

Discussion

Although in this experiment there was a slight improvement in the number of between-ferret choices in the differential reinforcement condition, no increase in ferret preferences was observed in the ordinary competitive choice trials. Because there were forty ferret-no ferret choices in

the differential condition, as opposed to twenty in the competitive choice, the difference between the two conditions could well be interpreted in terms of the number of all-or-none choices received by each group. The results would also seem to support the number-of-trials hypothesis advanced in Experiment 2 to explain the increase in number of discriminations observed in the all-or-nothing trials of Part 2, rather than the ease of discrimination alternative. The attempt, in the present experiment to create a learning set using ferret-no ferret choices can, therefore, be regarded as a failure. As in Experiment 1, there was a tendency for the wins per competition ratio to be higher when the subjects were acting as subjects rather than stimulus animals, although for one male on this occasion the opposite occurred.

The design of this experiment can be criticised in that it would have been quite possible to adopt both suggestions of Experiment 2, in that the easy discriminations could have been used over a large number of trials in order to create the appropriate set. Despite this possibility though it would seem that, as far as the competitive order is concerned, if it takes a similar number of trials to emerge as a behavioural determinant as a pair of visual stimuli in the ferret, it cannot be regarded as a significant social force. This conclusion is reinforced by the results of Part 1 of Experiment 2, in which it could be seen that even after the subject had shown itself able to make a discrimination between ferrets, it did not always do so. Thus, even if the competitive order does influence competitive choice behaviour, this influence is weak and very specific.

General Discussion

The negative conclusions of this study are very important in terms of the general interpretation of such competitive orders. In all of these experiments, and in that of Syme (1970), the paired comparison competitive trials produced a very good approximation of a linear hierarchy, in accordance with the Landau coefficient and these hierarchies, in general, proved to be reliable. Thus it would seem reasonable to label the acquired hierarchy as being representative of social dominance, which is the practice in many such competitive studies with different species (Candland and Bloomquist, 1965). Only when an attempt is made to relate the hierarchy to other social behaviour very closely aligned to the original does it become evident that an equally plausible interpretation of its meaning is that it represents consistent individual differences at a specific competitive task.

In postulating a dominance order, an implicit assumption is that each of the ferrets can readily identify each other as individuals, but in view of the poor competitive discrimination and the lack of individual preferences in the two differential reward experiments, it may be that the individual ferret does not play an important role in the laboratory organisation of this species, outside the breeding season. A second interpretation of this lack of discrimination could be, as suggested in Experiment 2, a lack of motivation on behalf of the ferrets to make such a choice. However, since Pollard et al used twenty-six trials per day on a similarly rewarded basis and obtained discriminations, this may be regarded as only a partial cause for any non-discriminations.

Finally, there have been two main findings from these

experiments, despite the preponderance of inconclusive results. The first of these has already been mentioned in the discussion of the second experiment. This study clearly demonstrates the limitations of attempts to describe the social organisation of a species purely by laboratory methods. A more valuable study to enable understanding of the ferret should have been undertaken in the field; especially following the results of the first experiment. Had this been done, the reasons why such an experiment had failed at least had the possibility of being discovered. As it was, those results which were obtained in later experiments were equivocal, and any attempt to fully evaluate them required field data.

The second, and perhaps more important finding in this study, is that a linear competitive order in a species does not necessarily represent an effective social organisation. Studies finding such orders should demonstrate their generality and social importance. It no longer seems advisable to avoid the question of the significance of demonstrating the generality of the order by stating that there may be a number of "dominance" orders in that species (Lindzey, Manosevitz and Winston, 1966; Baeninger 1970; van Kreveld, 1970). If each of these orders proved to be as specific as the one studied in these experiments, the concept of dominance would become useless. It would also seem that it should not be an automatic assumption that, just because the animals appear to be competing (as in this study), a social relationship has been established. When two animals are competing it must be demonstrated that they are acting as a pair, rather than as two individuals. For any motor task, regardless of its particular response requirements, reliable individual differences in performance can probably be established

in small groups of any species, if measures are sufficiently complete. Behaviourists who find competitive orders should therefore prove that their dominance measures are not merely reflections of these individual differences.

FIGURE 2.1

A diagrammatic representation of the single dominance tube. S - start box, D - decision space, P - pipe, R - reward box. Scale: pipe diameter = 10 cm.

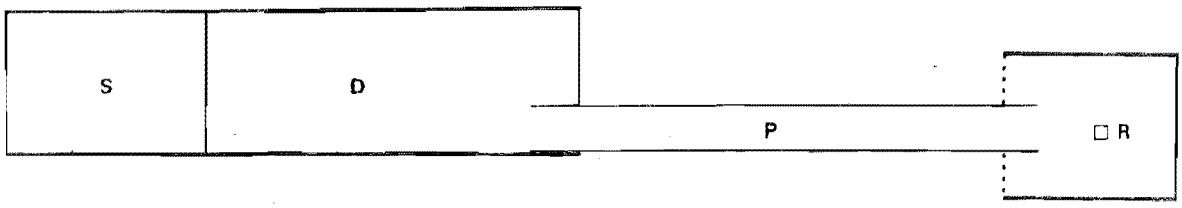


FIGURE 2.2

A diagrammatic representation of the double dominance tube. C - choice box, O - one-way doors, S - start box, G - guillotine doors, D - decision space, P - pipe. Scale: diameter of pipe = 9.0 cm.

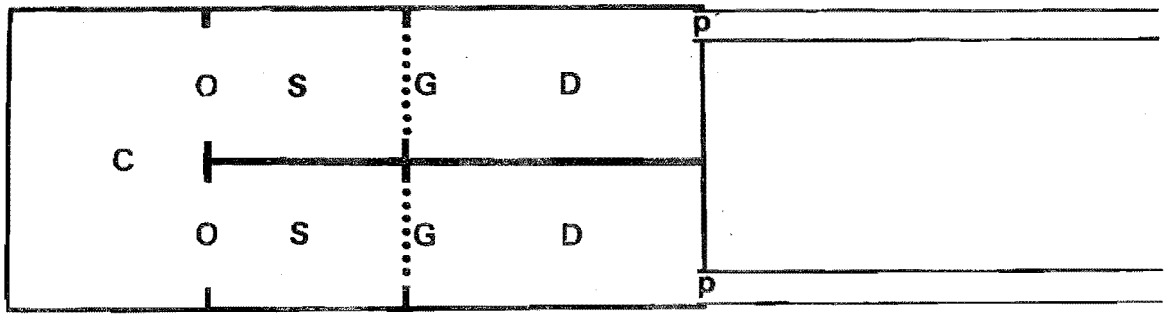


FIGURE 2.3

A graph showing the sequence of choices made by ferret M3 when presented with a choice between ferret M5 and ferret M1.

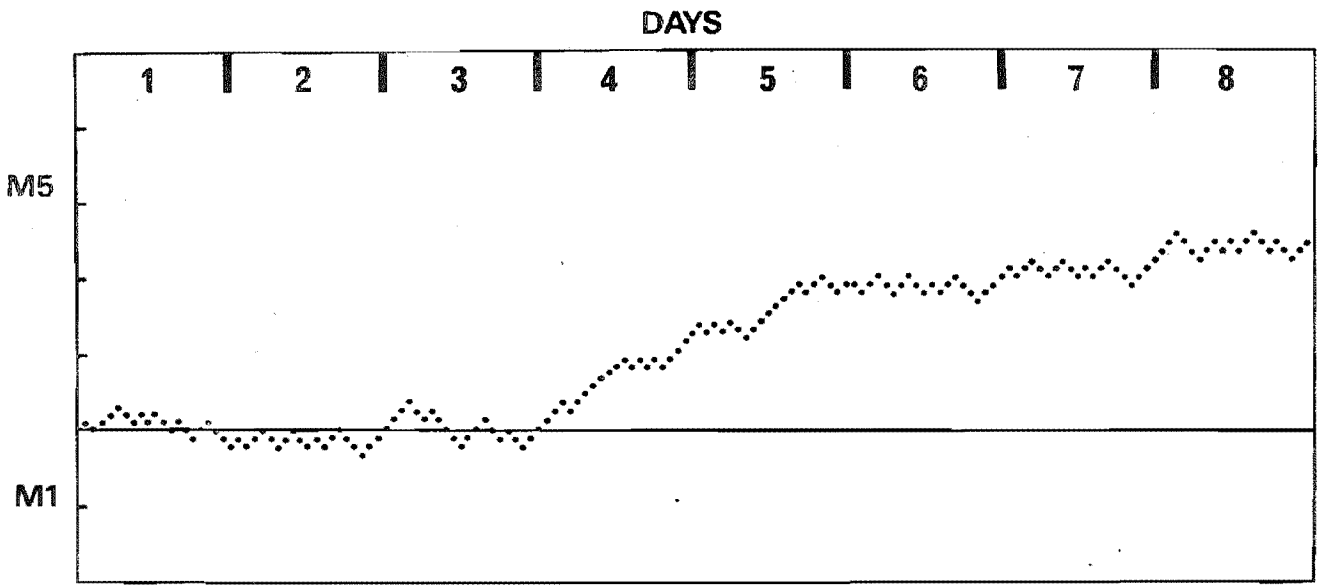


FIGURE 2.4

A graph showing the sequence of choices made by ferret M3 when presented with a choice between ferret M4 and M2.

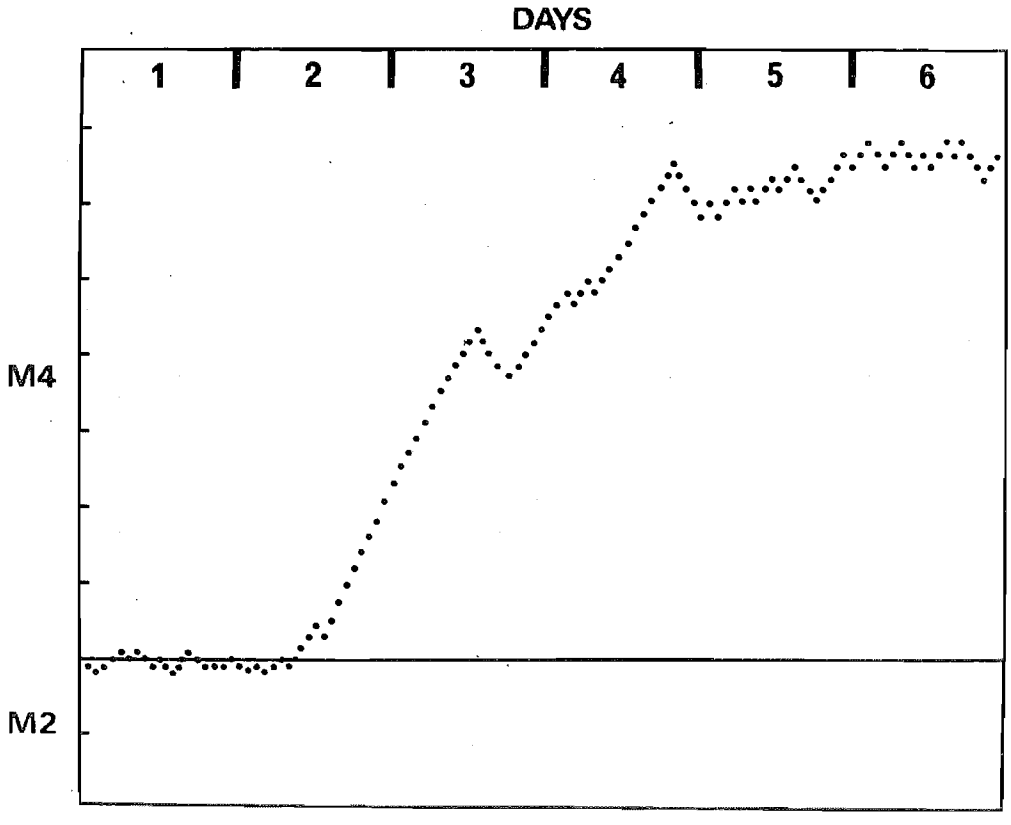


FIGURE 2.5

A diagrammatic representation of the reward order. An arrow leading from one subject to another indicates that this subject was always rewarded in the presence of the other animal.

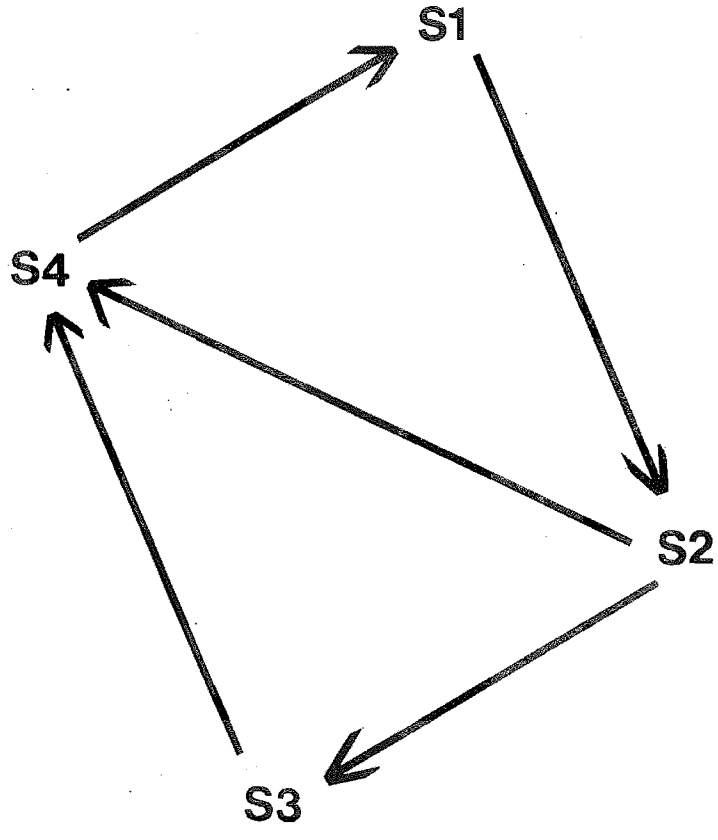


TABLE 2.1

Coefficients of agreement between the three rounds of paired comparison competition.

	Rounds	
	1 and 2	2 and 3
Males	0.2	0.6^{+}
Females	0.6^{+}	0.6^{+}

+ : p 0.05

TABLE 2.2

Competitive orders obtained over the second and third rounds of paired comparison competition.

BEFORE SOCIAL PREFERENCE						AFTER SOCIAL PREFERENCE					
Round 2 Males						Round 3 Males					
Subjects	1	2	3	4	5	Subjects	1	2	3	4	5
1	X	+	+	+	+	1	X	+	+	+	+
2	+	X	-	+	+	2		X	+	+	+
3	+		X	-	+	3			X	+	+
4				X	+	4				X	+
5		(h=0.6)			X			(h=1.0)			
Round 2 Females						Round 3 Females					
Subjects	1	2	3	4	5	Subjects	1	2	3	4	5
1	X	+	+	+	+	1	X	+	+	+	+
2		X	+	-	+	2		X	+	+	+
3			X	+	+	3			X	+	-
4				X	+	4				X	+
5		(h=0.8)			X	5		(h=0.8)			X

h : Landau coefficient $(0 < h \leq 1)$

TABLE 2.3

Ratio of wins to competitive encounters for each subject.

Male Subjects	Paired comparison	As chooser	As stimulus
1	5.67	5.32	3.91
2	0.84	7.00	3.77
3	0.84	0.62	0.21
4	0.67	0.97	0.49
5	0.46	0.30	0.08

TABLE 2.4

Ratio of wins to competitive encounters for each subject.

Female Subjects	Paired comparison	As chooser	As stimulus
1	2.20	2.24	1.83
2	2.02	5.10	1.67
3	0.57	0.10	0.13
4	0.78	2.24	0.80
5	0.50	0.62	0.88

TABLE 2.5

Average proportions of time spent by each subject with each choice animal - MALES.

	Male Subjects	CHOOSER 1	2	3	4	5	Total
CHOICE	1	X	0.51	0.56	0.45	0.49	2.01
	2	0.51	X	0.44	0.67	0.44	2.06
	3	0.49	0.50	X	0.54	0.56	2.09
	4	0.43	0.56	0.40	X	0.51	1.90
	5	0.57	0.43	0.60	0.34	X	1.94

TABLE 2.6

Average proportions of time spent by each subject with each choice animal - FEMALES.

Female Subjects		CHOOSER 1	2	3	4	5	Total
CHOICE	1	X	0.54	0.48	0.56	0.46	2.04
	2	0.42	X	0.53	0.52	0.49	1.96
	3	0.54	0.46	X	0.48	0.56	2.04
	4	0.50	0.45	0.46	X	0.49	1.90
	5	0.54	0.55	0.53	0.53	X	2.15

TABLE 2.7

The choice behaviour of each male in the ferret-nothing choice situation.

Male Subjects	Ferret	Unoccupied	No Preference
1	-	1	3
2	-	3	1
3	-	1	3
4	-	3	1
5	-	2	2
Total	0	10	10

TABLE 2.8

The choice behaviour of each female in the ferret-nothing choice situation.

Female Subjects	Ferret	Unoccupied	No Preference
1	-	-	4
2	-	-	4
3	-	-	4
4	-	2	2
5	-	-	4
Total	0	2	18

TABLE 2.9

Number and competitive outcomes of the choices made by the males.

		OUTCOME		
		Win	Loss	Total
CHOICE	Reinforced	81	42	123
	Nonreinforced	47	70	117

TABLE 2.10

Details of the results of the choice experiment.

	Subjects	Length of Series	Longest Sequence	Pair	p
FEMALES	1,2,3	15	7	1,2	0.001
	1,2,4	14	3	-	-
	1,2,5	33	29	1,5	0.001
	1,3,4	14	2	-	-
	1,3,5	7	2	-	-
	1,4,5	18	12	1,5	0.001
	2,3,4	4	2	-	-
	2,3,5	7	2	-	-
	2,4,5	33	33	2,5	0.001
	3,4,5	16	15	4,5	0.001
MALES	1,2,3	9	2	-	-
	1,2,4	7	2	-	-
	1,2,5	4	1	-	-
	1,3,4	7	2	-	-
	1,3,5	6	2	-	-
	1,4,5	10	5	1,5	0.05
	2,3,4	10	3	-	-
	2,3,5	8	2	-	-
	2,4,5	5	1	-	-
	3,4,5	10	2	-	-

p = probability of the length of the longest sequence occuring.

TABLE 2.11

The number of times each male was found in the same square as every other male over the ten triads.

Male Subjects	1	2	3	4	5	Total	Number of Significant Sequences
1	X	8	6	8	11	33	1
2		X	11	11	6	36	0
3			X	6	4	27	0
4				X	8	33	0
5					X	29	1

Grand total = 158

TABLE 2.12

The number of times each female was found in the same square as every other female over the ten triads.

Female Subjects	1	2	3	4	5	Total	Number of Significant Sequences
1	X	16	13	14	46	89	3
2		X	7	4	38	65	2
3			X	4	2	26	1
4				X	17	39	0
5					X	103	4

Grand total = 322

TABLE 2.13

The perfect linear hierarchy shown by the subjects of Experiment 3 in the third and fourth rounds of competition (h = 1).

Male Subjects	1	2	3	4	5
1	X	+	+	+	+
2		X	+	+	+
3			X	+	+
4				X	+
5					X

CHAPTER THREE

THE ORGANISATION OF EXPERIMENTS USING THE LABORATORY RAT

C H A P T E R T H R E E

The following series of rat studies were conducted to determine the validity of the commonly used measures of competitive dominance: the dominance tube (Schumsky and Jones, 1966) and the limited access situation (Bruce, 1941). Before this could be done, however, there were two studies which provided important indirect evidence as to the desirability of applying the concept of dominance to the rat which required investigation.

The first was a study reported by Ruskin and Corman (1971b) which apparantly provided strong support for the use of the concept of dominance for the limited access competitive orders. These authors found that increasing the motivation of their subordinate subjects from 24 to 72 hours food deprivation did not affect their competitive performance as compared with the dominant rats which remained at the 24 hour deprivation level. As a consequence of these results Ruskin and Corman concluded that the effects of the dominance order overcame the effects of a substantial change in motivation. They did not, however, provide individual data in order to assess quantitatively the change in feeding behaviour over the competitive period invoked by their increase in deprivation level. The first rat study reported here (Chapter 4) provides this data in order to clarify the relationship between feeding behaviour and competitive performance in the limited access situation.

A second study which had an indirect bearing on the use of the concept of dominance in the rat was that of

Latané, Schneider, Waring and Zweigenhaft (1971). This study was an attempt to test for specificity of social attraction in grouped rats in an open field situation. They found that there was no differential spatial distribution of three rats when two cagemates and one strange rat, previously housed under identical conditions, were placed together in an open field. As a result Latané et al concluded that there was a general lack of individual discrimination in this species.

If this is the case it would seem impossible to contemplate the existence of a dominance hierarchy in rats under such conditions. Unfortunately, however, the design of Latané et al's experiment has a flaw in that since each animal was unfettered in the open field the behaviour of the "strange" rat had not been considered. Whereas both cagemates had a choice between a familiar and unfamiliar animal no such choice was available to the third rat as both other subjects were strangers. Thus assuming that animals housed under equivalent social conditions exhibit equal sociability no differences in social distances could have been expected. For a preference situation to have been created all subjects should have had a choice between familiar and unfamiliar animals. This condition is provided in the second of the series of rat studies described in Chapter 5, by the development of a photographic technique for measuring the spatial distribution of larger numbers of rats than those enabled by Latané et al's method.

Finally in Chapter 6 both the limited access and dominance tube measures are examined in terms of their response requirements to ascertain their validity as measures of social dominance in rats.

CHAPTER FOUR

THE RELATION BETWEEN FEEDING BEHAVIOUR AND PERFORMANCE IN THE LIMITED ACCESS TEST FOR COMPETITIVE DOMINANCE IN THE RAT

CHAPTER FOUR

Introduction

Stable food dominance relationships have been demonstrated between pairs of rats maintained at equal levels of deprivation in a variety of competitive situations (Schumsky and Jones, 1966; Becker and Flaherty, 1968; Hoyenga and Rowe, 1969). But the evidence on the effects of varying the deprivation condition of one partner in such a relationship is contradictory. Using the dominance tube, Hsaio and Schreiber (1968) manipulated the motivational level of their submissive animals by (1) not feeding them when they lost a competition, (2) prefeeding the dominant animal 8 g of food and the submissive animal 3 g, and (3) placing the dominant animal on ad lib. feeding while continuing to deprive the submissive animal. Their results showed that a relative increase in deprivation in the submissive animals was followed by a substantial improvement in competitive performance. Ruskin and Corman (1971) however, using a limited access food hopper, found no improvement in the performance of submissive animals when they were deprived for up to 72 h and dominant animals were maintained on a 24 h deprivation schedule.

There are two possible explanations for the discrepancy. Either the different levels of food deprivation affected competitive behaviour in the dominance tube but not in the limited access situation, or the differences in level of food deprivation used by Ruskin and Corman were not large enough for any change in competitive behaviour to be recorded. The first alternative would suggest that motivational factors are important in the dominance tube but not in the equally popular

limited access measure. If this is the case further analysis of each method is required if both situations are to be regarded as interchangeable measures of food dominance in the rat. If the second explanation is valid it would demonstrate that alterations in deprivation should be accompanied by quantitative data reflecting the change in feeding behaviour associated with the motivational changes. Neither Hsaio and Schreiber nor Ruskin and Corman provide such data. The present study was designed to test the second hypothesis.

In order to increase the motivation of their submissive Ss Ruskin and Corman extended deprivation from 24 to 72 h whilst Hsaio and Schreiber provided ad lib. food; but neither study presented data to show the degree to which feeding behaviour was altered by these manipulations. Experiment 1 was designed to provide this information. In Experiment 2, feeding behaviour in a noncompetitive situation was related to competitive behaviour in the limited access situation.

EXPERIMENT 1

Subjects and Apparatus

The Ss were 8 naive male hooded rats (Otago strain N.Z.B.W.S.), 120 days old at the beginning of the experiment. Ss were housed together in a cage measuring 0.75 x 0.33 x 0.45 m high for 2 weeks before the experiment began and were maintained on a reversed light-dark schedule throughout. The apparatus consisted of a wooden box measuring 0.33 x 0.33 x 0.33 m with illumination provided by a 40 W fluorescent lamp through a plexiglass roof. A plexiglass door formed one side of the box and allowed direct observation. A raised mesh-steel floor allowed spilled food to fall out of reach of Ss. The

remainder of the apparatus was painted in white semi-gloss. A food trough measuring 2.50 x 8.75 x 3.10 cm was attached at floor level to a side wall.

Procedure

A 24 h food deprivation schedule was imposed and Ss were habituated to the apparatus in pairs for 15 min per day for 10 days. By this time all Ss were approaching the food trough and taking wet mash within 10 sec of being placed in the apparatus. Individual measures were then taken of the time spent at the food trough, and the amount eaten was measured by weight gain over the 15 min test period. These measures were taken once for each of three deprivation conditions in the following order (1) after 24 h food deprivation, (2) after 24 h ad lib. food, (3) after 72 h food deprivation. To control for effects of social facilitation on eating behaviour (Harlow, 1932), Ss were fed in pairs, the members of which remained constant throughout both experiments.

Results and Discussion

The amount of food eaten and the time spent at the food trough by each S are shown in Tables 4.1 and 4.2. The Wilcoxon Matched Pair Signed Ranks Test showed significant differences between the amounts eaten in the ad lib. and 24 h conditions ($d = 0$, $p < 0.01$) and between the ad lib. and 72 h conditions ($d = 0$, $p < 0.01$), but not between the 24 h and 72 h conditions ($d = 5$, $p \geq 0.05$). The time spent at the food trough showed a similar pattern. A significant difference was found between the ad lib. and 24 h conditions ($d = 3$, $p < 0.05$) and between the ad lib. and 72 h conditions, but not between the

24 and 72 h conditions ($d = 6$, $p \geq 0.05$).

These results suggest that Ruskin and Corman did not succeed in producing a significant alteration in feeding behaviour and consequently it is not surprising that their manipulation of deprivation level was not followed by a change in dominance relationships.

EXPERIMENT 2

Subjects and Apparatus

The food trough was removed from the apparatus previously used to expose a 3.43 cm hole in the same wall at floor level; this food hole gave access to a trough mounted outside the apparatus. The Ss used in the first experiment served as Ss for Experiment 2.

Procedure

Ss were given two days ad lib. feeding to let them recover from the 72 h deprivation period, and were then habituated to the modified apparatus for 15 min per day for 10 days. By this time all Ss were reaching through the hole to eat food from the trough within 10 sec of being placed in the apparatus. During the adaptation period they were maintained on a 24 h deprivation schedule and were not fed in the home cage. One S from each pair was then placed in a cage in which food was provided ad lib. for 24 h prior to competitive testing. The other S was maintained on a 24 h deprivation schedule. For competitive testing both members of a pair were placed in the apparatus for 15 min, and the time spent in command of the food trough was measured. The amount eaten

was determined by weight gain over the 15-min period. The deprivation conditions of the members of each pair were then reversed, and each pair was tested again in the competitive situation.

Results and Discussion

The amounts eaten and the times spent in command of the food trough under the two levels of deprivation are shown in Tables 4.3 and 4.4. All subjects gained higher scores on both measures of competitive performance under the 24-hour condition than they did under the ad lib. condition. In both cases the difference was found to be significant using the Wilcoxon matched-pairs signed-ranks test when these values were compared with the expected 50% level of performance (Times: $d = 0$, $p < 0.01$; Weights: $d = 1$, $p < 0.01$). These results confirm the claim of Hsaio and Schreiber that a relative increase in the deprivation level of the submissive animals is followed by an improvement in competitive performance and enables one to generalise this statement to the limited access situation.

TABLE 4.1

Amount of food (g) eaten by eight rats under three levels of food deprivation.

Subject	Hours of food deprivation		
	0	24	72
1.	3.5	5.9	13.9
2.	3.7	8.1	12.6
3.	1.6	8.1	8.1
4.	2.5	8.6	6.8
5.	2.8	8.1	14.3
6.	2.0	5.9	4.2
7.	5.9	9.5	14.5
8.	2.5	7.9	7.9
M	3.1	7.8	10.4
SD	1.3	1.2	3.7

TABLE 4.2

Amount of time spent at food trough (sec) by eight rats under three levels of food deprivation.

Subject	Hours of food deprivation		
	0	24	72
1.	570	706	840
2.	589	520	781
3.	267	784	817
4.	425	753	799
5.	666	861	849
6.	653	816	810
7.	746	790	854
8.	785	810	797
M	587.4	754.8	818.3
SD	159.9	98.6	24.9

TABLE 4.3

Amount of food (g) eaten in competition under two levels of food deprivation. Brackets indicate competition pairs.

Subject	Hours of food deprivation	
	0	24
1.	2.9	6.9
2.	2.8	10.9
3.	3.4	7.9
4.	2.3	3.9
5.	2.1	12.1
6.	0.7	2.0
7.	2.4	16.3
8.	2.3	7.9
M	2.4	8.5
SD	0.7	4.3

TABLE 4.4

Amount of time spent in command of food trough (sec) under two levels of food deprivation. Brackets indicate competition pairs.

Subject	Hours of food deprivation	
	0	24
(1.	143	598
2.)	273	638
(3.	305	546
4.)	321	534
(5.	212	526
6.)	248	490
(7.	342	786
8.)	55	550
M	237.3	583.4
SD	91.4	87.5

CHAPTER FIVE

EVIDENCE FOR CAGEMATE PREFERENCE IN THE LABORATORY RAT

C H A P T E R F I V E

Introduction

Several recent studies have claimed to measure sociability and social preference in rats (Tolman, 1961; Shelley and Hoyenga, 1966, 1967; Salazar, 1968; Latané et al, 1968, 1969, 1970, 1971, 1972). Before Latané's experiments the settings used for such measurements involved the reaction of the subject to a caged animal. The main problems encountered with these measures, however, were the unknown effect of caging the stimulus animals (Guhl, 1942) and the relatively small percentage of time spent by the subject in the vicinity of the stimulus rat (Walton and Latané, 1972).

An alternative method introduced by Latané (1968) was to estimate the average distance between two subjects within a circular open field. Time subjects were in contact was employed as a further measure of sociability. However, this procedure still presents a number of problems. Firstly the observer is physically limited to recording the movements of a small number of animals simultaneously in the field. In order to study the social behaviour of grouped animals this requires the removal of subjects from the majority of their cagemates. For example Latané, Cappell and Joy (1970), comparing the sociability of isolates and rats housed in varying degrees of social density, found a difference between isolated and grouped animals but none between the particular group conditions. However, although subjects in each test pair were identically housed, individual rats were placed with unfamiliar animals in the test situation. Since both rats were strangers it is possible that any group-specific effect was obscured.

An experiment designed to test the specificity of attraction of rats for cagemates (Latané, Schneider, Waring and Zweigenhaft, 1971) illustrates another aspect of this problem. Although all subjects were housed in pairs, trios were placed in a circular open field so that, in the test situation, two rats were cagemates and the third a stranger. It was argued that if an attraction did occur between familiars the average distance between these subjects should have been less than that between unfamiliar animals. Using this method, however, the role of the free-moving unfamiliar animal could not be controlled. To this animal both other subjects were unfamiliar and no choice was available. Assuming that identical cage conditions lead to equal sociability no difference in distances would have been expected. At least four animals would have been required to present a choice to all subjects.

A further criticism of Latané's technique concerns the use of the round open field. Presumably this was used to avoid position preferences, but this method presents problems similar to those encountered in the social preference study. Just as the third subject in the trio had no choice between animals, one of a pair of rats within the round open field has only one "landmark"; that of another rat. Had a choice between another animal and a corner been provided it is possible that the subject may have preferred the environmental landmark. This criticism is supported by the fact that most laboratory rats are housed in rectangular cages. If corner preference outweighs any observable social effect the latter cannot be regarded as the more important constituent of the animal's behavioural repertoire. It must be admitted,

however, that the methodological correctness of the use of the square arena must sometimes be considered with regard to the convenience of the round open field. Animals caged in differing housing conditions may also exhibit differences in position preferences which would have to be observed and incorporated in comparative sociability analyses. This would provide us with a more coherent picture of interaction between the animals' social and spatial behaviour than in the round open field. But in experiments in which sociability is a supplementary measure, or for situations in which the number of subjects is limited, the round open field may prove to be the more practicable alternative.

The following method was developed to overcome my previous criticisms of Latané's procedure.

Method

A time-sample photographic technique, similar to that used by Herron and Frobish (1969) was adopted in order to obtain a record of the movements of a group of animals within a large square open field measuring 1.2 x 1.2 x 0.4 m. The floor of the field was divided into 16 squares each of area 0.3 x 0.3 m. The field was painted brown with the lines dividing the floor painted white. Illumination was provided by six 40 W fluorescent lamps placed around the perimeter and 1 m above the centre of the field.

Subjects

The Ss for Experiment 1 were 12 male hooded rats (N.Z.B.W.S.) approximately 100 days old at the time of the experiment. Two groups of 6 Ss were housed in cages measuring

0.5 x 0.3 x 0.3 m high for 2 weeks before the experiment and were maintained on a reversed light-dark schedule throughout. Ad lib. food and water was provided. One group of animals was marked on the tail with purple alcohol dye 2 h before testing.

The Ss for Experiment 2 were 12 male hooded rats approximately 250 days old at the time of the experiment. Two groups of 6 Ss were caged under conditions identical to those of Experiment 1 but for 20 weeks before the experiment began. No dye was used on either group.

The Ss for Experiment 3 were 16 male hooded rats 70 days old at the time of the experiment. Two groups of 8 Ss were housed in cages measuring 0.7 x 0.4 x 0.3 m high at 40 days of age. No dye was used on either group.

Procedure

The same procedure was used for the three studies. Rats from both groups were placed alternately into the same corner of the field and, after 1 min had passed, photographs were taken every 30 sec for a 10 min period. In this way 20 photographs of the whole field were obtained. These photographs enabled the exact positioning of each rat every 30 sec over the test period. The natural black markings of the hooded rats proved to be distinctive enough for the individual recognition of each rat in the 20 photographs.

Analysis

Both of Latané's sociability measures can be established using the present method. An approximation of the time-in-contact measure, which is probably the more

powerful of the two, was obtained by counting for each animal in every photograph the number of familiar and unfamiliar rats occupying the same square. While Latané estimated the second measure of sociability as being the shortest distance between two animals,[1] using the photographs it was possible to obtain this data not only with greater precision but also in terms of the normal spatial behaviour of the rat within the enclosed field area.

The mean percentages of observations of differentially housed rats occupying the inner four squares of an open field (by the back legs) similar to that used in the present study were derived from time-sample data for 19 isolated and 42 grouped animals (Syme, 1971) and are presented in Table 5.1. This shows the frequently observed position preference of rats for the perimeter of the field. None of the centre frequencies exceeded 12% as compared with an expected frequency of 25% if the distribution of the animals had been random. A series of Sign Tests revealed that all of these differences were statistically significant ($p < 0.01$). It seemed, therefore, that distances between rats occupying perimeter squares should be measured around the perimeter. The convention thus adopted was to regard the distance between two rats in perimeter squares as being the shorter distance between the two, as measured around the perimeter. The distance between a "centre" rat and another in the field was measured as the linear distance between the two, since there is no evidence to suggest

1. Although this author does not state which part of the rat was used as the index, the present study has presumed that these distances were head-to-head distances and were calculated accordingly in this study.

that "centre" rats will return to the perimeter at any particular place. It is probable that, using a round open field and a small number of animals, the adoption of this form of measurement would have little impact on the final analysis.

Results

The Ss in Experiment 1 showed a preference for cagemates on both sociability measures. Using the Wilcoxon Matched Pair Signed Ranks Test the average distance between cagemates for the twelve animals was significantly less than between unfamiliar animals ($T = 8$, $p < 0.02$).[1] On the proportion-of-animals-in-the-same-square measure familiar Ss were shown to have significantly higher values than unfamiliar Ss ($T = 7$, $p < 0.01$). No significant difference was observed between groups on either sociability measure using Mann-Whitney U tests (Distances: $U = 14$, $p > 0.05$, Same square: $U = 13$, $p > 0.05$).

For Experiment 2 although there was no significant difference between the average distance between familiar and unfamiliar Ss ($T = 29$, $p > 0.05$) the proportions of familiar animals occupying the same square for the twelve Ss was significantly greater than that for unfamiliar animals ($T = 12$, $p < 0.05$). There was no significant difference between groups on either sociability measure (Distances: $U = 17$, $p > 0.05$, Same square: $U = 6$, $p > 0.05$).

In Experiment 3, as in the previous experiment, there was no significant difference between the average distance

1. All probabilities are two-tailed.

between familiar and unfamiliar Ss ($T = 59$, $p > 0.05$). Only one of the groups was significantly more sociable towards cagemates on the "same square" measure ($T = 2$, $p < 0.02$). There was no significant between-group difference on either sociability measure (Distances: $U = 24$, $p > 0.05$, Same square: $U = 20$, $p > 0.05$).

Two representative photographs, from which these results were calculated, may be seen in Plates 5.1 and 5.2. The means for all conditions may be seen in Tables 5.2 and 5.3.

Discussion

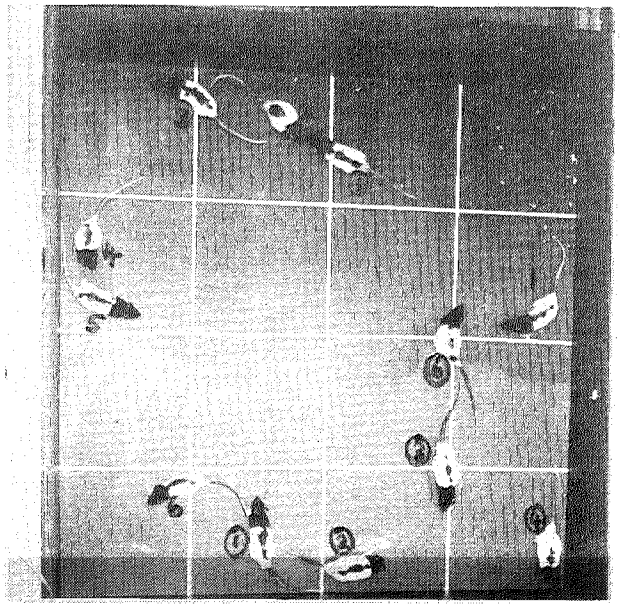
The results for the first two experiments suggest that both groups of animals were equally sociable, but when faced with a choice of distributing themselves near cagemates or unfamiliar animals they chose their cagemates. In the third experiment only one group chose their cagemates even though both groups came from identical cage environments. While these results may or may not mean that cagemates develop specific "attachments" all three studies support the hypothesis that cagemates can recognise each other under certain conditions. One such condition could have been the presence or absence of dye which may have aided the recognition of familiar animals. Of all the studies observing two or more albino rats in an open field together, not one mentions the problem of individual recognition by the observers. If dye was used it seems that this may have influenced the results obtained. Other conditions may include the age at which the groups are caged together, the age of the animals at testing, the group size, and the size of the home cage.

Distance does not appear to be a satisfactory measure of sociability in that it is not known how close a rat must be to another before it is a relevant stimulus in a dynamic group situation such as that produced by the present method. The proximity measure avoids this difficulty in that only animals in the same square are considered, but it is clear that sociability measures for grouped animals should be taken in the presence of all their cagemates as a prerequisite for meaningful results. A high correlation ($r_s = 0.86$, $p < 0.01$) was found to exist between distances measured around the perimeter of the field and those measured linearly as in Latané's studies. The convention adopted by the present study does provide an increase in the sensitivity of sociability measures which are usually confined to a relatively small area, in that the range of possible distances is increased from the diameter to half the circumference of the field. This could prove to be especially valuable in the analysis of group dispersions in the type of study previously examined.

Although the results presented in this study cannot be regarded as conclusive, the use of the photographic technique described shows that the sociability behaviour of grouped rats cannot be assumed to be as simple as previous studies have hitherto suggested.

Plates 5.1 and 5.2

Two representative photographs from which proximity and distance measures were calculated.



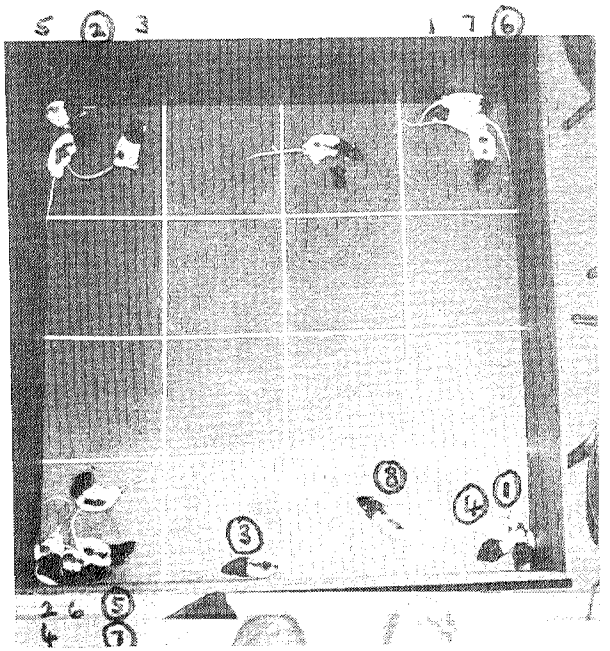


TABLE 5.1

Mean % observations of animals occupying centre squares in an open field (N = 62).

CAGING	TEST	
	Single	Paired
Isolated	7.3	5.4
Grouped	8.4	11.2

TABLE 5.2

The average distance (cm) per photograph between the: A - familiar animals (Group A + Group B), B - unfamiliar animals (Group A + Group B), C - Group A, D - Group B.

	A	B	C	D
Experiment 1	65.05	64.68	60.72	61.38
Experiment 2	87.45	85.47	88.66	86.24
Experiment 3	81.84	84.81	79.86	83.82

TABLE 5.3

The mean proportion per photograph of the numbers of animals in the same square as: A - familiar animals (Group A + Group B, Experiment 3 Group A only), B - unfamiliar animals (Group A + Group B, Experiment 3 Group A only), C - Group A, D - Group B.

	A	B	C	D
Experiment 1	0.12	0.09	0.13	0.11
Experiment 2	0.12	0.09	0.15	0.10
Experiment 3	0.20	0.17	0.20	0.18

CHAPTER SIX

AN ANALYSIS OF THE LIMITED ACCESS MEASURE OF SOCIAL DOMINANCE IN RATS AND FOWLS

CHAPTER SIX

Introduction

The limited access measure of competitive dominance in rats was introduced by Bruce (1941) and has since proved to be a popular technique (e.g. Uyeno, 1960; Rosen, 1961, 1964; Becker, 1965; Spigel, Trivett and Fraser, 1972). At first the measure consisted only of an upturned box placed over a drinking tube in such a way that only one of a pair of rats could drink at a time during a restricted period. The animal spending the longer time in command of the water source was regarded as being dominant. Since then, although there have been minor changes from study to study, the principle has remained the same. Despite the popularity of the limited access situation, however, there has, as yet, been no standardisation of procedure or measurement, and no attempt has been made to validate it as a measure of dominance.

Although all limited access studies create a situation in which only one of a number of animals can feed at a time, the amount of deprivation imposed, the length of time allowed for competition, and the numbers of animals competing vary considerably. Deprivation periods have varied from five hours (Baeninger, 1970) to seventy-two hours (Ruskin and Corman, 1971b), the competitive period from two minutes (Hoyenga and Rowe, 1969) to fifteen minutes (Ruskin and Corman, 1971a, 1971b) and the number of animals competing from two to four. The variable representing competitive performance also differs. Although most authors regard time spent in command of the reward source as the appropriate measure, Hoyenga and Rowe suggest that the amount consumed in such a situation is a better measure.

It is clear that in each of these studies the particular deprivation periods and time limits have been chosen because the authors have supposed that, if placed in the apparatus individually under the competitive conditions all subjects would eat or drink for almost the entire time available. As yet no study has presented data in support of such an assumption.

Apart from methodological considerations, the lack of pre-competition data for individual animals obscures the validity of the limited access situation as a measure of dominance. Van Kreveld (1970) has defined dominance as "-a priority of access to an approach situation or of leaving an avoidance situation." If dominance is to be useful as a concept applicable to rats within the limited access situation, therefore, the term "priority" must be quantitatively demonstrated. This can only be done by relating individual performance on both time and weight variables to subsequent competitive measures. A poor correlation between individual and competitive measures would indicate that the performances of some subjects in a group had changed in comparison with the others. If the competitive measure then proves to be reliable one may assume that the animals which have improved in relation to their individual data have priority over those who have not. In this way one can classify these animals as being more dominant, in accordance with van Kreveld's definition.

It is clear, therefore, that in using raw times or weights as measures of competitive performance it has been assumed that all animals will perform equally if no competition is imposed. This is unlikely. It remains to be

shown that limited access "dominance" studies have not merely been measuring individual differences in skill in a variety of eating and drinking situations.

The first experiment examines the need for systematisation in procedure in limited access studies, by relating individual measures of time spent drinking or eating, and amounts consumed, to subsequent competitive performance. It also provides a further comparison of time and weight as dependent variables in dominance studies. But most important, it is an attempt to evaluate the limited access situation as a measure of dominance in rats.

EXPERIMENT 1a

Subjects

The Ss were 7 male hooded rats (Otago Strain N.Z. B.W.S.) 100 days old at the beginning of the experiment. Ss were housed together in a cage measuring 0.75 x 0.33 x 0.45 m for 2 weeks before the experiment began and maintained on a reversed light-dark schedule throughout. Ad lib. food was provided. Each animal was dyed in a distinctive pattern to enable individual recognition.

Apparatus

This consisted of a metal box measuring 0.33 x 0.33 x 0.33 m with illumination provided by four 10 W bulbs contained in a lighting unit in the roof. A perspex door formed one side of the box and allowed direct observation of Ss. The remainder of the apparatus was painted in a white semi-gloss. A calibrated drinking tube of diameter 0.45 cm was attached to a side wall 15.24 cm above floor level.

Procedure

It was decided to study individual levels of performance using a water deprivation situation. This was because, in order to obtain water, S was forced to remain at the drinking tube thus making time-spent-drinking measures simple to record. If a food reward had been chosen time-spent-eating measures could have been complicated by S, in the absence of a competitor, taking food away from the trough. A 23.5 h deprivation schedule was adopted. Typical competitive periods of 2 and 4 min were chosen.

Ss were deprived and habituated to the apparatus for 10 min over 10 days, after which drinking time was limited to 4 min. Twelve daily individual measures were then taken of time spent drinking and amounts drunk over this interval. These measures were then repeated with 2 min allowed for drinking. Each day Ss were provided with ad lib. water for 30 min after testing.

Results

The times spent drinking and the amounts drunk by each rat were summed over 6-day blocks (equivalent to the six competitions which each S would have undergone in a paired comparison measure of dominance).

Four minute drinking period : Reliability of the two measures was determined by calculating coefficients of concordance within blocks and Spearman rank correlations between blocks. Table 6.1 shows the values of coefficients of concordance for Blocks 1 and 2 on the time and volume measures. While one of these is low for Block 1, both values are highly significant in Block 2. In both blocks the agreement for

volumes is higher than that for times. The correlations between Blocks 1 and 2 were 0.68 ($p > 0.05$) for volumes and 0.71 ($p < 0.05$)[1]. for times. For both blocks combined, the mean time spent drinking was 146.1 sec out of a possible 240. The correlation between the times and weights measures of Block 2 was 0.79 ($p < 0.05$).

Two minute drinking period : The mean time spent drinking was 116.6 sec out of a possible 120. Since all Ss spent almost the entire period drinking, individual differences on the time measure disappeared under this condition. Values of the coefficients of concordance for the volume measures were 0.54 ($p < 0.05$) for Block 1 and 0.67 ($p < 0.05$) for Block 2. The Spearman rank correlation between blocks was 0.92 ($p < 0.01$). On the volume measure the Spearman rank correlation between Block 2 of the 4-min condition (Days 7 to 12) and Block 1 of the 2-min condition (Days 13 to 18) was 0.75 ($p < 0.05$). The average amount drunk during a 6-day block in the 2-min condition (27.35g) was significantly less than that drunk (39.09g) during the first 4-min condition.

Discussion

The high and significant relationship within and between blocks on the volume measure indicates reliable individual differences in the amount of water drunk. Because the subjects drank for virtually the entire available period during the two minute sessions, and because the amount drunk was significantly less than that consumed in the four minute sessions, one may postulate that the individual differences

1. All probabilities for Spearman rank correlations are one-tailed.

in amounts drunk reflect the skill of subjects at gaining water from the drinking tube. The high correlation between the volume measure in the four minute and two minute period does, however, give some credence to the hypothesis that these individual differences are in part representative of small differences in motivation. But even if these motivational differences exist, the amounts consumed by the more highly motivated animals are limited by the physical dimensions of the drinking tube and the small time period available. It is also impossible to differentiate as to whether the animals are more highly motivated because of the deprivation period or the nature of the task set. Since it may be considered that the decrease in amounts consumed and the equality of the amount of drinking time for each subject have exerted a greater influence on drinking behaviour than the small difference in motivation, I have adopted a skill interpretation of these individual differences. But it must be remembered that this interpretation may contain some degree of motivational contamination.

As a result of these individual differences, Hoyenga and Rowe's proposal that total weights gained in competition be used as measures, must be regarded with caution. To use these measures it would seem necessary to give each subject a weighted score, in accordance with its skill, and in this way it may be possible to raise the correlation between time and volume measures. This suggestion is investigated in Experiment 1b.

Another important methodological consideration can be seen from the time data. The average time spent drinking was only 146 seconds. Given that each animal can be allowed

120 seconds in a four minute competitive period, it can be seen that all subjects can drink 82% of the normal amount without competition. Since the mean for the two-minute measures ($\bar{x}$ = 116 sec) represents almost all the available time, one may assume that, for this period, almost 100% competition is guaranteed.

Thus it is clear that an empirical approach must be taken when the competitive period is chosen for the dominance studies. This period should be, at most, that time for which all animals will continuously eat or drink under the deprivation conditions imposed, especially if the subjects are tested in pairs.

EXPERIMENT 1b

Introduction

The purpose of this study was to relate previously established individual differences in skill to performance in a two minute competitive situation, given that a suitable competitive period had been determined. However, in view of the evidence of James (1961) and Tolman (1965), that competitive performance in dogs and chickens is related to the degree of social facilitation operating in the social eating situation, the possibility that the mere presence of another animal could affect drinking called for investigation. Thus individual skills needed to be related to performance in a noncompetitive paired comparison social situation. Only then might individual performance be usefully related to competitive performance, again in a paired comparison situation. In spite of the measurement problem mentioned earlier, the

investigation was extended to include food as well as water measures, since most of the limited access studies have been concerned with eating.

Subjects

For the drinking situation the Ss were those used in Experiment 1a, while for the feeding condition a further 7 Ss of the same age, strain and sex were introduced. These were raised, housed and adapted under the same conditions as the first Ss, and subjected to the same deprivation schedule, this time for food rather than water.

Apparatus

The apparatus for the water dominance condition was the same as that used in Experiment 1a. For the social-drinking measures a second drinking tube was placed 4.6 cm from the first. Later, for competitive measurement, a 3.43 cm hole was exposed in the wall of the box 15.24 cm above the floor. A drinking tube was recessed in this hole 2.5 cm from the wall surface. This tube rested on the bottom of the hole.

The apparatus for the food observations consisted of a wooden box measuring 0.33 x 0.33 x 0.33 m with illumination provided by a 40 W fluorescent lamp through a perspex roof. A perspex door formed one side of the box. The remainder of the apparatus was painted with a white semi-gloss. A raised meshed-steel floor was used to ensure the removal of any excess or spilt food, which took the form of wet mash. A food trough measuring 6.0 x 8.0 x 3.0 cm high was attached to one wall at floor level for the individual and social eating

conditions. For the competitive condition this trough was removed to the outside of a 3.43 cm hole in the wall of the box; this arrangement permitted only one rat at a time to feed from the trough.

Procedure

Drinking : A further 6 days of individual measures on single animals were taken, followed by two 6-day rounds of noncompetitive social drinking in a randomly-chosen paired comparison design. Time spent drinking and the amount drunk were recorded, the second measure being obtained by weight gain. Six days of individual assessment then followed, which were succeeded by two more rounds of social drinking which, in turn, led to one 6-day block of individual measures. The hole in the wall was then exposed and the Ss were introduced to this singly for six 6-day blocks. Following this, two blocks of paired comparison competition, two blocks of individual drinking, and finally two blocks of paired comparison competition were conducted. A summary of this procedure is presented below.

Days	Block	Condition
1 - 6	b_1	Baseline - normal drinking tube
7 - 18	$s_1 - s_2$	Social drinking - noncompetitive
19 - 24	b_2	Baseline - normal drinking tube
25 - 36	$s_2 - s_3$	Social drinking - noncompetitive
37 - 42	b_3	Baseline - normal drinking tube
43 - 78	$cb_1 - cb_6$	Baseline - recessed drinking tube
79 - 90	$c_1 - c_2$	Competition
91 - 102	$cb_7 - cb_8$	Baseline - recessed drinking tube
103 - 114	$c_3 - c_4$	Competition

For the paired comparison competitive rounds the sequences of competitive pairs were chosen randomly with three pairs

of rats run daily and the remaining animal being placed in the apparatus individually for 2 min. Using this procedure one round of paired comparison competition was completed over 7 days. On completion of each day's sessions all Ss were given free access to water for 30 min. The amount consumed in competition by each S was determined by weight gain. For these measures each S was weighed immediately before and after competition and the difference recorded. The accuracy of weighing was established using two independent observers to record volume and weight changes and the error was found to be on average ± 5%.

Eating : Six 6-day blocks of individual measures of time spent eating and amounts consumed (by weight gain) were taken over a 2-min period. This was followed by two randomly chosen paired comparison rounds of noncompetitive social eating and a further block of individual eating. The hole in the wall was then exposed and one block of individual eating followed and finally, two rounds of competition. A summary of the procedure is given below.

Days	Block	Condition
1 - 36	$b_1 - b_6$	Baseline - inside trough
37 - 48	$s_1 - s_2$	Social eating - noncompetitive
49 - 54	b_1	Baseline - inside trough
55 - 60	cb_1	Baseline - outside trough
61 - 72	$c_1 - c_2$	Competition
73 - 84	$cb_2 - cb_3$	Baseline - outside trough
85 - 96	$c_3 - c_4$	Competition

The procedure for the paired comparison rounds of competition was the same as that for water competition. In view of the results of the motivation experiment (Chapter 4) that animals deprived of food for 24 h will eat for about 13 min,

2 min seemed to be a suitably rigorous competitive period which allowed direct comparison with the water study.

Results

Each S received a time and weight score for each 6-day block (6 sessions over 7 days during competition). These were calculated by summing the daily weight gains and times spent in command of the reward source over the 6 sessions. The 7 Ss in each group were then ranked according to these totals and the ranks were used to calculate the correlations between blocks on each measure. Because of the lack of individual differences in time scores during the noncompetitive sessions (see Experiment 1a) correlations involving this measure were determined for competitive sessions only.

Drinking : Fig. 6.1 shows that the rank ordering of amounts drunk by single rats correlated well with performance in the social drinking situation. The first block of baseline measures correlated significantly ($r = 0.88$, $p < 0.05$) with the first block of social drinking. This social drinking measure ($s_1 - s_2$) showed marginal reliability ($r = 0.71$, $p < 0.05$). The next baseline condition (b_2) again correlated highly with the third round of social drinking s_3 ($r = 0.96$, $p < 0.01$). Greater reliability was observed for the social drinking on the third and fourth blocks, s_3 and s_4 ($r = 0.83$, $p < 0.05$). This data indicates that the presence of another rat has little differential effect on the performance of Ss.

A t test for related samples (Winer, 1962) revealed no significant difference between the amounts consumed between b_1 and s_1 or between b_2 and s_3 ($\bar{X}b_1 = 33.35g$, $\bar{X}s_1 = 32.00g$,

$t = 0.86$, $df = 6$, $p > 0.05$; $\bar{X}b_2 = 33.50g$, $\bar{X}s_3 = 34.90g$, $t = 2.37$, $df = 6$, $p > 0.05$). Thus any effects on drinking behaviour during competition cannot be attributed to either social facilitation or inhibition.

The baseline measures b_3 were correlated with the rank order of the baseline measures in the first 2-min block of Experiment 1a, and a high value resulted ($r = 0.75$, $p < 0.05$). This demonstrates that the individual differences in drinking skill were reliable over a period of 9 weeks.

Fig. 6.2 demonstrates the effect of changing the drinking conditions to those suitable for competition; that is, recessing the drinking tube. This procedure was followed by depressed baseline reliability for the next four blocks (cb_1 - cb_4) suggesting that the rats had to learn to adjust to the new drinking situation - probably because the tube was resting on the bottom of the recess.

Figs. 6.3 and 6.4 represent the correlations between baseline and competitive weight gain measures and the correlations between competitive rounds on both time and weights measures. The first points shown in Fig. 6.3 are important. The correlation between amounts drunk in the final pre-competition baseline (cb_6) and the first round of competition (c_1) has a high and significant value ($r = 0.93$, $p < 0.01$). It is also interesting to note that the correlation between the weights on the final baseline (cb_6) and the total times on the first round of competition was also high ($r = 0.79$, $p < 0.05$). <u>This indicates that initial skill at the competitive task is closely related to competitive performance.</u> While there was no change in the performance of each S in relation to other members of the group on the

weight-gain measure, there was a small increase in variability in moving from baseline to competitive conditions (S.D. cb_6 = 2.62g, S.D.c = 3.81g). The reliability correlation is high between the first and second rounds of competition ($r = 0.93$, $p < 0.01$).

Baseline measures cb_7 and cb_8 show a high correlation with each other ($r = 0.93$, $p < 0.01$). But cb_7 did not correlate highly with the second round of competition, c_2 ($r = 0.43$, $p > 0.05$) or the previous round of baseline, cb_6 ($r = 0.21$, $p > 0.05$), and cb_8 did not correlate highly with the following round of competition, c_3 ($r = 0.25$, $p > 0.05$). The third and fourth rounds of competition correlated highly with each other ($r = 0.88$, $p < 0.05$) while the second round of competition, c_2, did <u>not</u> correlate highly ($r = 0.57$, $p > 0.05$) with the third round of competition. Correlations between each round of competitive times may be seen in Fig. 6.4. It is clear that, under these conditions, time proved to be an unreliable measure of competitive performance.

To this point, only the absolute measures of time and weight have been used in the analysis. This follows the convention adopted by most authors in competitive studies of this nature (Candland and Bloomquist, 1965; Hoyenga and Rowe, 1969; Baeninger, 1970; Spigel, Trivett and Fraser, 1972). Becker and Flaherty (1968) suggest two possible variations on this sort of analysis in rat studies. The first is to regard the numbers of wins per round of paired comparison competition as the index of dominance. This proved to be unsuitable for the present experiment. The second alternative was to use the proportion of time per individual competition as the index of dominance. These proportions are summed over

the entire paired comparison to give a total "dominance" score for each individual. This is an appealing idea for the analysis of weight-gain data, since the daily fluctuations in the amounts eaten or drunk are noticeable even within such a short testing period. A proportional measure would eliminate these from the competitive evaluation as well as dampening the error due to differences in skill.

Accordingly, proportional measures were taken from the competitive data. Both time and weight proportions proved to correlate highly with absolute measures, with the lowest correlation observed ($r = 0.89$, $p < 0.01$) being between the weights on the first round of competition. Fig. 6.5 shows the reliabilities of the proportional weights and times over the four rounds of competition and, as can be seen, these measures give a similar overview to that provided by the total measures.

Fig. 6.6 shows that the correlation between total times and weights measures were variable over the four rounds of competition. High correlations were, however, observed on Rounds 1 ($r = 0.89$) and 3 ($r = 0.73$). In general, the results support the conclusions of Hoyenga and Rowe (1969), that the two measures cannot be regarded as equivalent. A suggestion for resolving this discrepancy was made in the first part of the present study. This was that, if the differences in skill could be accounted for, a close relationship would be observed between times and weights. It is now clear that this cannot be the case, simply because of the unreliability of the time measure.

Although in this experiment the need to cope with these individual differences in skill has been superseded by the unreliability of the times measures, in some situations

this procedure still may have to be contended with. Such a case would be an occasion similar to that occuring in the Baeninger (1970) study in which stable orders did occur on the time measure for groups of four animals tested together. If the weight measure was also stable in this situation, a closer investigation of the relationship between the two variables could be attempted.

It must also be remembered that, even if no relationship occurs between times and weights, some attempt at skill compensation needs to be made to enable one to find the order of competitive success on the weights measure. Fortunately, because of the high correlation between competitive and baseline measures, this has proved to be unnecessary in this particular situation in the first two rounds. However if the first round, for example, is adjusted according to individual performances in cb_8, by dividing the totals consumed by each animal into that consumed by the least competent animal, and then multiplying the competitive weights of each S by this fraction, a low correlation results with the original order ($r = 0.46$, $p > 0.05$). This may, of course, represent an over-compensation in that the stability of the ingestive skill may have some relationship with the correlation between baseline and competition, but even so it may be seen that the rank orders on the weight-gain variable could be substantially changed by any procedure of this nature. Only more rigorous experimental investigation will, however, reveal the correct analytical procedure for such circumstances.

Food : Results for the food dominance experiment proved to be no mere repetition of those found for water. As may be seen

in Fig. 6.7, the reliability of the baseline measures is lower than that for the drinking condition, although after the first block (b_1) all correlations were significant beyond the 0.05 level. The noncompetitive social eating condition did not appear to have an effect on the baseline orders (see Fig. 6.8), a result consistent with those obtained in the drinking condition. The first block of social eating (s_1) correlated significantly with the preceeding block of baseline performance, b_6 ($r = 0.75$, $p < 0.05$), but the reliability of the social-eating measure proved to be nonsignificant ($r = 0.67$, $p > 0.05$), although only slightly lower than the other reliability coefficients. In spite of this, the second round of social eating (s_2) correlated well ($r = 0.82$, $p < 0.05$) with the immediately following block of baseline measures, b_7.

A difference from the drinking situation can be seen, however, when baseline totals in b_6 are compared with the totals for each S in s_1, the first round of social eating. A t test for related samples showed a significant increase in the amount eaten in the social condition ($\bar{X}b = 17.0g$, $\bar{X}s_1 = 19.9g$, $t = 4.9$, $df = 6$, $p < 0.01$).

It is also noteworthy that, unlike the effect of moving the drinking tube, shifting the feeding trough did not affect the reliability of the baseline measures, between b_7 and cb_1 ($r = 0.82$, $p < 0.05$).

The competitive data in the eating situation also differ from those in the drinking situation (see Fig. 6.9). The rank ordering for the weight-gain measure in the first round of competition correlated significantly with the immediately preceeding round of baseline, cb_2 ($r = 0.71$, $p < 0.05$) as did the second round of competition ($r = 0.71$,

$p < 0.05$). Unlike the water-competition group, the correlation between the weight gain order in the final pre-competition baseline (cb_2) and the total-times measure in the first round was low ($r = 0.21$, $p > 0.05$). A high reliability was shown for the weight gains between the first two rounds of competition ($r = 0.82$, $p < 0.05$).

As in the water condition the following block of baseline measures (cb_3) correlated only moderately ($r = 0.41$, $p > 0.05$) with the preceeding round of competition (c_2), but it did prove to be reliable as its correlation with cb_4 shows ($r = 0.94$, $p < 0.01$). Cb_4 did not correlate highly with the third round of competition (c_3) which immediately followed. However the third round of competition correlated significantly with baseline cb_3 ($r = 0.74$, $p < 0.05$) while the fourth round of competition correlated highly with the final baseline, cb_4 ($r = 0.82$, $p < 0.05$). This continued correlation between baseline and competition was not observed in the water competition situation. As may be seen in Fig. 6.10, consecutive rounds of competition all correlate significantly with each other; this is again in contrast to the drinking situation where Rounds c_2 and c_3 did not correlate highly.

The time measures again proved to be somewhat unreliable, although the correlations between the first two rounds of competition was high ($r = 0.89$, $p < 0.01$).

For this group a comparison was also made between amounts eaten in the second round of social facilitation and the first round of competition. Since only half the time per animal was available in competition to that in the social facilitation experiment, the values for s_2 were halved. A t test for related samples showed that there was a

significant increase in the amount eaten per unit time in the competitive situation ($\bar{X}s$ = 10.5g, $\bar{X}c$ = 13.8g, t = 4.8, df = 6, $p < 0.01$). Unfortunately this statistic could not be calculated for the water group since there was a change in the diameter of the water tube from the social facilitation to the competitive measures. However since no social facilitation occurred in this situation, a comparison was made between the final baseline and the first round of competition. The resultant value was not significant ($\bar{X}s$ = 10.3g, $\bar{X}c$ = 12.1g, t = 0.56, df = 6, $p > 0.05$).

The analysis of proportional measures for food competition are shown in Fig. 6.11. It can be seen that a similar picture is obtained for the proportional-times measures as for the total times. The proportional weights, however, are less reliable than the total weights. Fig. 6.12 shows the relationship between the total and proportional measures over the four rounds of competition although, as in the water competition, the relationship between total and proportional times is high, the proportional and total weights correlate only moderately by the fourth round of food competition.

The relationship between the total times and total weights over the four rounds of competition are shown in Fig. 6.13. It can be seen that the correlations are always low.

As in Experiment 1b, attempts to compensate for individual differences in amount consumed were thwarted by the shift in competition baseline and the general unreliability in times measures.

Discussion

The results of the noncompetitive social condition show that the presence of another rat during testing did not alter the previously stable rank order of weight gains observed in the individual measures. This is in contrast with the results found for both dogs (James, 1961) and cockerels (Tolman, 1961) although it must be emphasised that there were considerable differences in method between this study and theirs.

Although the amounts of water drunk did not show an increase in the social-drinking condition, animals fed in pairs did show an increased consumption. This difference may be the result of the differing response required in the two situations. It is possible that the amount eaten could be increased by taking larger mouthfuls and spending less time chewing, while once a rat has reached a peak in licking at the water tube, the amount consumed is limited by the physical dimensions of the tube. A significant increase in the amount consumed in competition over that which would be expected was also observed in the feeding situation but not for drinking. This could, perhaps, be interpreted as demonstrating extra social facilitation caused by competition, but again could also be explained in terms of the differing response requirements of the food and water reward. During food competition, because the rat is not completely tied to the reward source, the possibility of reward alternation arises in that, while one animal is chewing the other animal can be at the reward source, with no disadvantage to either.

The modification of the apparatus for the competitive conditions demonstrated another difference between eating and drinking. In the drinking condition, the change in the response

necessitated by recessing the drinking tube, had a marked effect on the hitherto reliable individual differences in amounts drunk. On the other hand, shifting the food trough to the far side of a hole in the wall did not alter the baseline eating measures. This again is probably due to the different response requirements for feeding and drinking combined with the greater degree of change in the water response. The nature of the drinking tube is such that a subject is required to remain at the tube all the time while it is drinking, but the use of a feeding trough allows a rat to take a mouthful of food from the trough and then move away while it is ingested. This means that the rat is committed to the competition site only while it is taking a mouthful and this probably represents only a moderate proportion of the total feeding time. It is likely, then, that for both the general differences in the response requirements for eating and drinking, and the specific degree of change invoked in the drinking response by resting the tube at the bottom of the recess, that there was a greater disruption in drinking than feeding.

The need to learn the competitive response in the drinking condition has considerable methodological significance, as has the fact that it took eighteen days for individual differences to stabilise in the feeding condition. Hoyenga and Rowe (1969) claim that in using the limited access situation one avoids the problems associated with habituating subjects which are encountered with other competitive measures of dominance, for example the dominance tube (Schumsky and Jones, 1966). The present results indicate that this is not so. Individual differences in performance should be monitored

carefully and allowed to stabilise before competitive measures are taken, and it also must be remembered that the duration of the competitive period must be chosen with regard to the times spent eating and drinking under the deprivation conditions imposed.

The most important results obtained in Experiment 1b concern the relation between baseline and competitive performance. It is obvious that initial performance in water competition, as measured by both time and weight gain, is very closely related to skill at the competitive response. This relationship is even more clear-cut in the food competition situation; if only for the weight-gain measure. All four rounds of competition correlate highly with the final pre-competition block of baseline measures on the weight-gain measure. Both the first and second rounds correlate significantly with the final pre-competition block of baseline measures, while the third and fourth rounds correlate with one of the intervening baselines. It may be concluded, therefore, that the relationship between skill at the competitive task and competitive performance was high and consistent over the four rounds of food competition, and that any alterations in baseline performance were accompanied by appropriate changes in the competitive order.

The recurring relationship between baseline and competitive measures in feeding is not repeated in the drinking condition. In water competition the correlation between the third and fourth rounds with their preceeding baselines are low. Once again this could be due to the different responses required in the two situations. A distinction may be made between the skills involved in ingestion and the pushing

skills involved in gaining access to the food or water source. In the drinking situation skill at ingestion is probably less important than skill in gaining access, while the reverse holds for the eating situation.

These specific points apart, it is clear that the present results fail to provide support for the limited access situation as a measure of social dominance. Both food and water data point to the conclusion that it is the initial skill which governs the amount of reward obtained during competition.

For the dominance enthusiast a more hopeful observation is the finding that the third and fourth rounds of competition do not correlate highly with their companion baseline measures. This deviation might be attributed either to the appearance of a social order or to the acquisition of specific responses required to perform well when faced with another rat at the drinking tube. The latter explanation seems the more likely, since there had been ample time for dominance relationships to establish themselves in the home-cage situation, but it is still possible that these relationships did not emerge until the third and fourth rounds of competition. Unreliability in the time measures was not entirely unexpected, in view of the results of Becker and Flaherty (1968) who found, using groups of six rats, that reliability coefficients did not exceed 0.8 until after the tenth round of competition. This again suggests that the dominance order has to be learnt within the competitive situation, and that this order is just as likely to be a response specific order as it is to be a social one.

The use of proportional data, as suggested by Becker

and Flaherty (1968), resulted in a picture very similar to that provided by absolute data on the water measures, but for the weight gains in the food experiment the correlations between absolute and proportional measures was quite low by the fourth round of competition. Unfortunately these proportional weights did not prove to be reliable, so that the advantages of the use of proportional weights at this stage seem limited.

The correlations between time and weight measures proved to be variable, and generally low, as would have been predicted by the results of Hoyenga and Rowe (1969). Because the weights measures were the more reliable it seems as though they may be the better measure, although this point will have to be theoretically resolved.

The main question raised in this study remains to be answered; does the limited access measure, under these conditions, measure dominance? Evidence presented here suggests that it may not. A conclusive test as to whether the water-competitive test is response specific would provide the answer.

EXPERIMENT 2

Introduction

This experiment was conducted as a test of the hypothesis advanced in Experiment 1, that performance in the limited access situation is a reflection of the specific response requirements rather than a measure of social dominance.

As yet no evidence is available concerning the effect of altering the competitive response, on dominance orders in

rats, although Lindzey, Manosevitz and Winston (1966) have demonstrated a difference in dominance relationships obtained for mice in the dominance tube and limited access tests. They suggested that the differences were due to the difficulties experienced by mice in emitting "dominance" behaviour within the confines of the dominance tube. In taking two such very different situations, the theoretical implications of differing dominance relationships are avoided. If dominance orders change with each small change in response requirement, dominance becomes inadequate as a concept, since each order can reflect only the particular methodology which generated it. If one speaks of dominance orders in rats one does not expect to find a different order for every small change in response requirements. So far, those authors who have been adventurous enough to try more than one measure of competitive dominance and who have found a difference, have not been particularly concerned at this finding. Lindzey et al state that mice exhibit different orders for different measures, but indicate that they consider the limited access measure more valid. Cole and Shafer (1966) found different orders in cats using a W.G.T.A. situation and a version of the limited access situation. They stated that the difference may have been due to the fact that they had different sizes of competition groups, differences in the spatial characteristics of the two tests, or differences in the required response. If the orders did change merely because of different response requirements, then it would seem more parsimonious to suppose that the rank orders obtained are a reflection of ability at the task.

Thus it was decided to compare the dominance orders

in a group of rats tested on two different responses, while holding constant the group size and the general spatial characteristics of the task. This was accomplished by creating two competitive responses within the same experimental chamber, and determining rank orders on the two tasks using the paired comparison method. If the concept of social dominance is to have any generality at all, then the two orders should be highly correlated.

Subjects

The Ss were 7 male hooded rats (N.Z.B.W.S.) 100 days old at the beginning of the experiment. Ss were housed together in a cage measuring 0.75 x 0.33 x 0.45 m for 2 weeks before the experiment began and were maintained on a reversed light-dark schedule throughout. Ad lib. food was provided. Each animal was dyed in a distinctive pattern to permit identification.

Apparatus

This was the same as that used for the water dominance test in Experiment 1. A 3.43 cm hole was drilled in one wall, 15.24 cm above the floor. Within this, a drinking tube was suspended 2.5 cm from the inner surface of the wall, with its base resting on the bottom of the hole. A second hole at floor level was provided, permitting the animal to drink from a water trough outside the chamber. The two drinking situations were adjusted until the rates of water uptake from the two were equivalent.

Procedure

The Ss were habituated to the apparatus for 10 min per day for 10 days. Drinking time was then reduced to 2 min per day. A paired comparison procedure was then adopted, with the floor drinking and the rearing responses used on alternate days. For one round of competition then, each S would be involved, so far as was practically possible, with three competitions at the floor and rearing responses. Because of the number of Ss, one S was required to compete four times on one of the responses within a round.

The full paired comparison round for each of the responses was completed during the second combined round. For each of the combined rounds, the orders of competition were chosen randomly. Each day, the S which was not involved in competition was placed alone in the drinking chamber for the testing period. All Ss were given 30 min drinking ad lib. after each day's testing. Testing was continued until four rounds had been given on each of the two responses.

Results

Results for both time and weight measures are summarised in Figs. 6.14 to 6.17. The reliability coefficients have been adjusted using the Spearman-Brown correction since they were based on half the number of observations used in measuring the relationship between responses.

Both the absolute and proportional time measures show the development of a low correlation between the rearing and floor orders in contrast to the high reliabilities of these orders. The same trend is found in the proportional weight measures. However, the absolute weight measures, although

exhibiting somewhat lower reliabilities, show a consistent relationship between the two responses.

The pattern of reliabilities differs considerably between the absolute weight and time measures, and one may note that both proportional measures prove to be consistently more reliable than their respective absolute measures. The reliabilities of the absolute weight measures are markedly lower than those found in Experiment 1.

Discussion

The results of this experiment lend considerable weight to the hypothesis that the limited access situation provides a response-specific measure. Only the absolute weight measures show between-response correlations which are consistently comparable with their reliabilities, and even with this measure the slow emergence of a reasonable level of reliability (0.67 after eight weeks) is as consistent with the learning of the competitive response as it is with the emergence of social dominance. The proportional-weight measure provides strong support for the hypothesis; while the reliability values are high, (r = 0.86 and 0.79) the correlation between floor and rearing orders falls to 0.39. It should be remembered that this measure should be more highly regarded since the proportional measure compensates for daily fluctuations in consumption as well as providing some compensation for specific response skill.

Both time measures clearly support the response interpretation; the correlations between floor and rearing orders in the final round being only 0.36 for the proportional-time measure and 0.04 for the absolute-time measure, although

reliabilities at this stage were greater than 0.8. It is not surprising then, that Baeninger (1970) found a relatively low correlation between food and water dominance orders generated by a time measure. One suspects, however, that the low correlation found by Baeninger may be attributable to response rather than reward difference.

Some more positive evidence for the dominance position can perhaps be found in the relatively high correlations between floor and rearing orders in the initial round of competition. But if these are dominance orders, then they rapidly break down in the face of competition. An equally plausible interpretation is that very similar skills are involved in ingestion of water, while at the same time, rather different skills are involved in gaining access to the water tube in the competitive situation. During the first round of competition, the major factor determining the rank order of subjects is skill at ingestion, but over subsequent rounds skill at gaining access to the tube gradually develops, and this plays an increasingly greater part in determining the rank order of individuals. As different skills are required in gaining access to the two tubes, the subjects order themselves in different ways on the two tasks. To test the hypothesis that very similar skills are required in ingestion from the two tubes, a brief experiment was conducted. Seven rats with the same age, breeding, and caging history were adapted to the apparatus for ten days when placed on the same deprivation schedule. Baseline measures on the two tubes were taken during two-minute periods for twelve days. Amounts drunk from the two tubes correlated 0.93. Taken together with the finding in Experiment 1, that initial

competitive measures correlate highly with baseline measures, this result gives strong support to my hypothesis.

Besides the conceptual difficulties presented by this study for the application of the concept of dominance to competitive behaviour in the rat, further procedural differences have also been highlighted. In Experiment 1b, weight gain was considered as the more appropriate dominance measure because of its reliability. In this experiment, however, the time measures were considerably more reliable than the weights. Thus it would appear that the properties of the time and weight variables vary according to the competitive situation, which presents great difficulties for standardisation of analysis in limited access experiments using laboratory rats.

EXPERIMENT 3

Introduction

This experiment aimed firstly to examine the hypothesis advanced in Experiment 2, that the initially high correlation found for both times and weights between the two response orders could be interpreted in terms of the similar skills involved in ingestion at the two water sources, and secondly to provide a comparison of competitive behaviour in the laboratory rat and domestic fowl. Evidence obtained from the first two experiments suggested that the competitive behaviour of the rat, in the limited access situation, could not be regarded as representative of social dominance for two reasons. Experiment 1 showed that, for both food and water competition, initial competitive performance was dependent

on individual skill at the competitive response; this relationship being maintained in the food situation for later competition. Experiment 2 demonstrated that a small change in competitive response, in water competition, was sufficient to affect dominance orders in three out of four measures.

This situation may also be true for other species. Thus application of the concept of social dominance to competitive orders obtained for these animals may well be inappropriate. For this reason it is imperative that the competitive behaviour of classical dominance subjects, such as the domestic fowl, should be carefully re-examined.

Unfortunately little comparative data relating to competitive behaviour is available; in the only comparative study of this nature Candland and Bloomquist (1965) have examined the reliability of food competition orders on a similar task over a variety of species. In general they found that rat orders were less reliable than those obtained with cows. parakeets and fowls. However only the time measure was used and also, for the rats a total of nine three-minute competitions were held each day which, as is shown in the present study, is probably far too long a time period for rats during one day. Thus a repetition of the rat-fowl comparison along the lines of Experiments 1 and 2 seemed advisable. The competitive periods were chosen as suggested in Experiment 1a and weight gains, as well as times, were recorded. As in Experiment 2 both species competed on two similar responses. However on this occasion baseline measures of the amount consumed were taken before competition commenced. Rats were tested with both water and food reward, and fowls with food reward. The water measures enabled the hypothesis

advanced in Experiment 2 to be investigated, and the food data enabled a comparison between chickens and rats to be made, while competing for the same reward.

Subjects

Rats : The Ss were 14 male hooded rats (N.Z.B.W.S.) 100 days old at the beginning of the experiment. They were housed in two groups of 7 in cages measuring 0.75 x 0.33 x 0.45 m for two weeks before the experiment began, and were maintained on a reversed light-dark schedule throughout. Ad lib. food was provided for one group and ad lib. water for the other. Each animal was dyed in a distinctive pattern to permit identification.

Fowls : This experiment was originally designed as a single-sex study. Unfortunately sexing errors were made with the one day old chickens which were kindly donated as males by Hi Brid Chicks Ltd., Weedons. Because of the small numbers of animals originally procured, the degree of gentling required in order to obtain accurate weights, and the problems of providing replacements of the same age, the original Ss were retained in the experiment when the sex differences were discovered. Thus the Ss were 5 female and 2 male chickens of a broiler strain originating from a three-way cross, White Leghorn x Australorp x Rhode Island Red. They were 90 days old at the beginning of the experiment and had been housed together in a pen measuring 3.0 x 1.6 m for 40 days prior to experimentation. Ad lib. water and grit were provided throughout the experiment. Each animal was dyed with an alcohol dye to permit ready identification.

Apparatus

Rats : The apparatus used for the water competition was the same as that used for Experiment 2, while the apparatus for the food competition was the same as that used in Experiment 1 except that for the present study an identical food source was made available in the same wall though 15.24 cm above the floor.

Fowls : The apparatus was a version of the "wedge" technique used by Candland, Mathews and Taylor (1968), a diagram of which is shown in Fig. 6.18. The guillotine doors and lids were made from hardboard whilst the sides of the apparatus were constructed of slotted angle iron and chicken wire. The use of these materials enabled unrestricted observation of ongoing behaviour within the apparatus. The floor was slightly raised and constructed of steel mesh to remove any spilt or excess food. A small round plastic trough of 6 cm diameter was provided as a food source. This trough was alternated daily between a position at floor level and one 45.6 cm above the floor. The food trough was protected by a hardboard cover suspended 11.2 cm above it. This provided a further assurance that only one chicken could feed at a time.

Procedure

Rats : The food competition group was placed on a 23.5 h food deprivation schedule and the animals were habituated individually to the apparatus for 10 days for 10 min per day. Food was presented from either the floor or rearing source, with the responses alternated from day to day.

Individual measures were taken over a 2-min period of amounts eaten at both sources. These measures were

continued for 24 days with the responses being alternated from day to day. Four rounds of food competition were then conducted using the same procedure as that followed in Experiment 2. Throughout these measures the animals were allowed 30 min of ad lib. food after each day's testing.

The procedure for water competition was the same as that employed for food with 30 min ad lib. water being provided after each day's testing.

Fowls : The Ss were placed on a 24-h food deprivation schedule and were habituated to the apparatus for 10 min for 10 days; again the food sources were alternated daily. During this time the amount of time spent eating by each S was recorded. This information enabled the choice of a competitive period of 4 min; a time during which all Ss averaged at least 95% feeding on each of the 10 days. The procedure followed was then the same as that employed for rats. Individual measures were taken for 24 days of amounts eaten over the 4 min with the high and low responses being alternated. Four rounds of competition were then conducted in the same manner as that employed for rats for both responses. The food used was wet mash. Each day after testing the fowls were provided with a small amount of supplementary food, this consisting of wheat and fowl pellets.

Results

Baselines

The results for all individual baseline measures are shown in Fig. 6.19. All reliability coefficients in this analysis were adjusted using the Spearman-Brown correction since they were calculated from half the number of observations

as the correlations between the competitive responses. It can be seen that all groups showed reliable individual differences between the first and second 6-day blocks on the weight-gain measure. As in Experiment 1b the water measures show a greater reliability than the equivalent food measures in rats.

Times

The times spent in command of the reward source and the amounts consumed in competition were analysed in the same way as Experiment 2, and the results may be seen in Figs. 6.20 to 6.31. Each group gave a somewhat different profile. In the rat food-competition group, poor reliability was observed for total and proportional times on both responses, although on the total-time measure the final between-response correlation was relatively high ($r = 0.64$, see Figs. 6.20 and 6.21). The times measures for the water competition proved to be more reliable than those observed for food, although this reliability was slightly less than that observed for water competition in Experiment 2 (Figs. 6.22 and 6.23). As in Experiment 2, a low correlation was observed between responses on both total and proportional times during Rounds 3 and 4 ($r_{total} = 0.11$, $r_{prop.} = 0.29$). The time data for the fowls was highly reliable, with a high correlation occurring between responses on all rounds for both total and proportional measures (Figs. 6.24 and 6.25).

Weight Gains

Profiles for the weight-gain data also differ from group to group. Food competition orders proved to be less reliable than the equivalent water orders, on both total and

proportional weight gains (Figs. 6.26 to 6.29). In both groups these measures showed significantly high correlations between responses after the third and fourth rounds of competition. For the water-competition group this high correlation contrasts with the findings of Experiment 2, which demonstrated a steadily declining relationship between responses on the proportional weights measure as the experiment progressed. Figs. 6.30 and 6.31 show that the fowls differed markedly from the rats on the weight-gain measures. Although the total-weights measures exhibited a high reliability in the first two rounds for both responses, this reliability had decreased to zero ($r = 0.0$) for the floor response by the fourth round of competition, and the relationship between the responses was also low at this point ($r = 0.18$). However the proportional weights proved to be reliable and for the first three rounds there was a very high relationship between the responses ($r_{1,2} = 0.94$, $r_{2,3} = 0.86$) but on the third and fourth rounds this relationship dropped slightly to a value lower than that observed for either group of rats ($r_{3,4} = 0.64$). In interpreting the weight-gain measure in fowls it should be remembered that, as with the rats, there are initial individual differences in the amounts eaten in the competitive period and, consequently, some form of "skill" or "motivation" compensation must be allowed for these differences when deciding on the final competitive order.

The times/weight gain relationship

In experiment 1b it was noted that the relationship between total-times and total-weights measures varied. It can be seen that this is probably the case with these measures

in the fowl, simply because of the unreliability of the total weights. Consequently it was decided to correlate proportional measures since both proportional times and weights showed good reliability for this species. This procedure was also followed for the two rat measures. The results may be seen in Fig. 6.3$_2$ which shows that, even though for Rounds 2 and 4 the relationship between these measures is high for the fowl ($r_2 = 0.91$, $r_4 = 0.82$) it is lower in the first and third rounds ($r_1 = 0.50$, $r_3 = 0.64$). The water-competition rats show similar results, with the high correlations, in this case, occuring in the first and third rounds ($r_1 = 0.89$, $r_3 = 0.84$). For the food-competition rats the relationship between the proportional times and weights is always low.

Skill compensation

As in Experiment 1b attempts at skill compensation for weights in the first-round fowl data did not result in a high correlation between times and weights. A correlation between the total-time measures for the high response for Round 1 and the adjusted total weights revealed only a moderate value ($r = 0.43$) whilst the same correlation for the floor response was also quite low ($r = 0.57$). As in Experiment 1b the adjustment for skill was calculated by dividing the amount consumed by each S in baseline conditions into the amount consumed by the least competent animal. The subsequent competitive weights are multiplied by this fraction.

Numbers of wins

There is a third method of competitive scoring; that of the number of wins per round. This was ignored in the rat studies because it was too insensitive to differentiate

between single rounds of competition. However it has been used successfully in chickens by Candland, Mathews and Taylor (1968). Thus the number-of-wins scoring technique was adopted for the present experiment. As in the Candland et al study Coefficients of concordance were calculated between the four rounds of competition on both measures and both responses. Resultant values are shown in Table 6.2. Results of Spearman rank correlations between statistically reliable orders may be seen in Table 6.3.

Experiment 1b demonstrated a high relationship between individual weight-gain measures and the amount consumed in the first round of water competition, for rats. A similar correlation was calculated for each group in the present experiment, between the rank order of the 12 days baseline weight gains and the total weight order on the first round of competition on both responses. The results of these correlations may be seen in Table 6.4. Each group demonstrated a relatively high correlation between baseline and competition for one response but a low one for the other. Both the food and water competition rat groups showed a high correlation between the baseline order and the floor response (r_f = 0.86, r_w = 0.96) whereas the fowls showed a high correlation between baseline and competitive performance on the high response.

Spearman rank correlations were also calculated between the baseline-weights order and the total-times order on the first round of competition for each response. The resultant values may be seen in Table 6.5. The only high correlation observed was between baseline and competition on the floor response for the water-competition rats (r_w = 0.86).

Amounts consumed in Baseline and Competition

Amounts consumed in the first round of competition were compared with weight changes in the second block of baseline measures using a t test for related samples (df = 6). For the water competition both rearing ($\bar{X}_{baseline}$= 21.06g, $\bar{X}_{competition}$= 11.9g, t = 6.7, $p < 0.01$) and floor ($\bar{X}_b$ = 26.07g, $\bar{X}_c$ = 15.8g, t = 13.1, $p < 0.01$) responses demonstrated that the rats consumed significantly less in competition than in the baseline condition. In the food-competition rats there was no significant difference between individual amounts consumed and the weights of food eaten in competition, on either the rearing response ($\bar{X}_b$ = 14.1g, $\bar{X}_c$ = 14.4g, t = 1.35, $p > 0.05$) or the floor response ($\bar{X}_b$ = 16.2g, $\bar{X}_c$ = 14.6g, t = 1.02, $p > 0.05$). For the fowls there was also no significant difference between the amounts eaten in the baseline and competitive conditions for the low ($\bar{X}_b$ = 448.7g, $\bar{X}_c$ = 535.4g, t = 2.06, $p > 0.05$) or high ($\bar{X}_b$ = 460.9g, $\bar{X}_c$ = 503.7g, t = 1.94, $p > 0.05$) responses.

Aggression

A record was kept of the aggressive behaviour during competition in fowls. In all, 35 of the 168 competitive encounters resulted in aggressive pecking by one of the competitors. On 10 of these occasions the competitors were male-female pairs. The between-female aggressive episodes were too few to complete a full peck order, but a stable relationship was observed between the two males.

Discussion

The high correlations obtained between responses for the baseline measures for both groups of rats confirm

the hypothesis advanced in Experiment 2, that the ingestive skills required for both the floor and rearing responses are similar. Consequently it is not surprising that the first-round competitive orders for the two responses were highly correlated in Experiment 2, since ingestive skills have been shown to correlate well with competitive performance in the first round of competition.

The competitive time measures revealed that the fowls were the group which conformed to the concept of social dominance most clearly. A high reliability for both total and proportional times was observed between rounds, and an equally high correlation between responses. Both groups of rats proved to be unsatisfactory on the times measures; the water group because of the low correlation between responses, and the food group because of the general unreliability of their orders. It is also interesting to note that, as would be expected from the findings of Experiment 1b, competitive performance for food in rats continues to depend primarily on ingestive skills; the correlations between responses are of a comparable value to the reliabilities.

In this experiment the times results generally confirm those of Candland and Bloomquist (1965) that chickens are more reliable than rats, despite the excessive daily competitive requirements for the rats used in their study. However it should be remembered that the differences between the food and water competition groups in the rats are just as marked as those between species. Attempts to compare between species should, therefore, present a range of responses, dependent variables, and rewards, so that the degree of overlap can be determined more realistically.

This conclusion is further supported by the weight-gain data which shows a different relationship between groups than did the time variable. The final reliability of the total weight-gain measures for the fowls proved to be less than that for either rat group, and the correlation between responses was also low. However both groups of rats exhibited developing reliabilities on the total-weight measure with a similar relationship between responses. The proportional weight-gain data showed a different relationship between rats and fowls to that shown by the total weight gains. For this measure the fowls became more reliable than either of the rat groups, although the difference was only slight between the fowls and water-competition rats. It is notable, though, that as for the total weights the final between-responses correlation was the lowest for the fowl group. The relationship observed by Candland and Bloomquist (1965) for times is thus reversed on the weights measures, and for this variable the rat groups seem to show more reliability and generality than the fowls. Here again, though, any definitive interpretation awaits further data.

Perhaps the most important result of Experiment 3 concerns the relatively high correlation observed between responses on the proportional-weights measure of water competition in rats. This is in contrast with the results obtained in Experiment 2, in which this measure showed a decreasing relationship between responses as competitive testing progressed. Thus both weight measures in this experiment can be interpreted as demonstrating the generality of the competitive order in rats and the concept of dominance in rats. The issues raised by Experiment 2 cannot, however,

be dismissed immediately; the differences between responses in both experiments were slight, and the effect of this may be less for the weights measures than for the times. Both weights measures should therefore be examined in a study which allows the differences between response requirements for the subjects to be gradually widened. It must also be remembered that the problems of reliable individual differences and the high correlation between baseline and the first round of competition should also be dealt with before the weights can be regarded as an effective dominance measure in the rat. The consistent relationship between responses for food competition was expected from the results of Experiment 1b. Since food competition reflects ingestive skills, and these are similar for the two responses, comparable orders on both responses may be expected.

From the analysis of the round totals of all four measures it can be seen, therefore, that no group demonstrated an entirely satisfactory dominance order on all measures. The results also indicate that time and weight variables should be regarded separately in competitive studies, and that theoretical considerations as to the appropriate measure should be made.

Transformation of both time and weight data into the number of wins per round for analysis revealed that, as in the Candland et al (1968) study, the fowl orders were statistically reliable over the four rounds on both measures. The rats, competing for water, were reliable on the weights measure only, whereas the food-competition rats were unreliable on both measures. Only the fowls showed consistently high relationships between the two responses, although it is

interesting to note that a perfect correlation existed between the rearing and floor response on the weights measure for the water-competition group of rats. However these correlations between responses were calculated from the combined results of the four rounds of competition so that any developing differences could have been obscured. A second limitation of such an analysis is that, by reducing the data to a binary state of wins and losses, substantial sensitivity is lost and, as to whether such a win-loss dichotomy is meaningful, has still to be ascertained (Shibuk, 1971).

The correlations between baseline measures and the first round of competition for each group were calculated in order to confirm the findings of Experiment 1b, which showed that there was a high correlation between baseline measures and subsequent competitive performance. Such a relationship was not repeated for both measures in either group of rats. However both groups <u>did</u> show a significant relationship between the orders on the twelve days baseline and the first round of floor competition. Both groups showed a low correlation on the rearing response. However, a high correlation did occur between baseline and competition on one response for the fowls this occurred on the high response.

That there was only one significant correlation between baseline and competition for both groups is not altogether surprising. When two responses were required, as in this experiment, to complete one full round of competition on either response twice as much competitive experience had been gained as in Experiment 1b, and the time between the end of the baseline and the completion of the

first competitive round had consequently increased. The first factor could account for the low correlation in the water-competition group, since it was shown in Experiment 1b that the skill-competition correlation for this reward diminished rapidly as competitive experience was obtained. A temporal explanation would seem to fit the facts for the food-competition group. Since lower reliabilities for both baseline and competitive performance have been observed for the food reward in Experiment 1b, it might be expected that these reliabilities could decrease with the increased time lapse between observations. However it must be noted that the more physically complex rearing response was introduced in the present experiment for the food measures. Thus one might expect competitive skills to be of greater importance than in Experiment 1b, where only the floor response was used. This interpretation is supported by the low correlation between the baseline and the first round of competition for the rearing response in both groups of rats. Since this was the more physically demanding response for the animal to perform one would expect competitive skills to be of greater significance earlier in the competitive testing than for the floor response. Consequently the correlation with the baseline was found to be lower than that for the floor response. Further support for this theory is obtained from the fowl data. Here the high correlation occurred between the baseline and the first round of competition on the floor task. Since in order to reach this source of food the fowls were forced to squat, as opposed to the higher response which could be easily reached from a standing position, this too may be regarded as the more complex response.

An important aspect of the fowl data is that on

this baseline-competition relationship, the fowls did behave in a similar manner to the rats, and a significant correlation was observed between baseline and competition on one response. This finding tends to weaken the validity of applying the social dominance concept to the competitive behaviour of the domestic fowl, although it is obvious that an experiment of a similar nature to that of Experiment 1b will have to be undertaken before firm conclusions can be drawn.

It is also interesting to note that, when comparing the total weight gains in the second six-day block of baseline data with the total weight changes in the first round of competition, only the water-competition rats show a significant decrease from the individual to the competitive condition. This is extremely surprising since theoretically an average of only half the individual eating time is available to both rat and fowl in food competition, and all animals in both groups ate over half the amounts consumed in baseline conditions. It is possible that this increase could be attributed to the social facilitatory effects of competition but, in view of the short time periods employed for the competitive trials, it is probably due to the ability of the animals to alternate at the food source. For instance, while one animal is swallowing or chewing, another animal may be taking a mouthful, and thus a good proportion of the total amounts eaten individually can still be obtained.

This demonstrates a severe methodological limitation of the present sort of competitive experiment. If the subjects are gaining similar amounts of food to that which could be gained individually it is doubtful whether the situation can be regarded as competitive in nature. Fortunately this problem

can be easily solved, using rats, by introducing water as a reward and thus ensuring that all reward intake is restricted to a point source. However no such methodological adjustments can be made for the fowls which, when drinking, behave in such a manner that it would be even easier to alternate the occupancy of the reward source in a paired comparison situation. A possible improvement, for fowls, in this case would be to use a discrete reward experimental situation so that an all-or-none win could be recorded. Whether such a system would be representative of the general behavioural regimes prevailing in flocks of chickens is another matter. As Dimond (1971) points out, the occurrence of all-or-none competitive situations in any species under almost any conditions, is probably rare.

To conclude one can see that, although the traditional dominance animal, the domestic fowl, exhibits competitive behaviour more closely aligned to the concept of social dominance than rats, it is by no means certain that results from this species satisfy all the requirements of this concept. Both total and proportional weights measures require further investigation, as does the significant correlation between baseline and competition on the high response. The methodological problems involved with the use of fowls are also greater than those for the rats and, perhaps, an alternative form of competition will have to be devised. It must also be realised that the sex differences in this study could also tend to inflate the correlations between responses, especially if the sex differences reported by Domm and Davis (1948) extend to this experimental situation.

The rat groups also demonstrate that when the competitive behaviours of different species are to be compared, the comparison can be markedly affected by the competitive task, the reward, and the competitive period used. One thing is clear: further intra- and interspecific analyses of competitive behaviour will reveal far more interesting descriptions of behaviour than would be expected from the currently popular use of the concept of dominance.

General Conclusions

Little evidence in support of the validity of the limited access situation as a measure of social dominance in rats has been gained from this study. Experiment 1b demonstrates that the weight-gain measure, as advocated by Hoyenga and Rowe is dependent upon skill at the competitive response. This dependence lasted for all four rounds in the feeding condition and for the first two rounds in the drinking competition.

Experiments 2 and 3 demonstrate that it is unlikely that the remaining rounds can be interpreted in terms of dominance, since there was a low correlation in both experiments between times measures on two very similar water-competition responses, while in Experiment 2 a low correlation between responses was also observed on the proportional-weights measures. The total weights in both Experiments 2 and 3 had an unacceptably low reliability for water competition. Only the high correlation in Experiment 3 between responses on both total and proportional weights show any sign of generality of the water-competition order. In view of the small difference

between the competitive responses, the high correlation between baseline and competitive measures, and the ample time which was available in the home cage in which these orders could have been established, this evidence for the dominance hypothesis is extremely weak.

Overall, the results of this study lead one to doubt that the majority of studies which have claimed to be measuring dominance in rats in the limited access situation have, in fact, been doing so. Except for two studies (Hoyenga and Rowe, 1969; Hoyenga and Lekan, 1970) all authors have used time as the indicator of dominance, and there has been no evidence from the present study of any generality of this measure. Even in the two studies which have used weight gain as a measure, it seems that the results can more parsimoniously be interpreted in terms of individual differences in skill at the competitive response.

It is clear that those studies which have related differences in early and social experience to performance in the limited access situation (for example, Uyeno, 1960; Rosen, 1961, 1964; Becker, 1965a; Becker and Gaudet, 1968; Becker and Ezinga, 1969) might all benefit from reinterpretation along the lines suggested here. The same may be said for those studies (for example, Uyeno, 1966; Stewart and Palfai, 1967) which relate hormone or drug levels to dominance as measured by the limited access situation. These results also tend to invalidate the proposal of Spigel, Trivett and Fraser (1972), that social grooming be regarded as a measure of dominance, since their justification for this statement was a correlation between social grooming and the performance in water competition in a limited access measure.

If the findings of the present study are combined with those of Lindzey, Manosevitz and Winston (1966), who found little correlation between the performance of mice in the limited access situation and the dominance tube, as well as those of Boice, Hughes and Cobb (1969) and Wechkin and Reid (1970) who showed that competitive orders in gerbils are response specific, the application of the concept of competitive dominance to rodents generally would seem unconvincing.

Despite the high correlation between aggression and competition found by Candland et al (1968), the results obtained with the fowls in the limited access situation would suggest that further work should be done before the competitive behaviour of this species can automatically be assumed to be representative of social dominance. It also appears that there is methodological uncertainty as to whether the limited access situation represents an appropriate measure for this species. Further research, firstly along the lines of Experiment 1b of this study, and secondly using a more sophisticated test of generality, should provide data of methodological and theoretical interest for this species.

The limited access situation has been introduced as an index of dominance in a number of other species in which aggressive behaviour is not easily observable under stable social conditions. For example, Candland and Bloomquist (1965) used the measure with cows, sheep, parakeets, rats and hamsters; Boelkins (1967) with monkeys; Cole and Shafer (1966) with cats and James (1949) with dogs. In general, attempts to validate these measures (if there have been any) have depended upon a correlation with aggressive behaviour.

However the results of the present study suggest that the competitive tests themselves should be analysed in terms of their response requirements and generality, if a valid measure is to be acheived. A good example of this need may be seen in the rat data, where, even though Ruskin and Corman (1971a) report a high correlation between the aggressive responses of the animal within the apparatus and its limited access competitive performance, this study using a response type of analysis failed to validate the limited access situation as a measure of dominance.

Although the present study suggests that the limited access situation does not measure social dominance in the laboratory rat, this may be because (as Baeninger suggests for aggression) the high degree of inbreeding in laboratory strains has removed social dominance from the animals' behavioural repertoire; or it could mean that the particular strain of laboratory rat used in this study does not utilize social dominance as a social mechanism. This study also concentrated exclusively on the paired comparison competitive method; a practice which is common, although unjustified, in much of the literature concerning competition. The study should, therefore, be repeated, with varying numbers of animals competing, and using a variety of strains and housing conditions.

In conclusion this study represents the beginning of the analysis of competitive behaviour in two species using a very specific situation only. Further work is required, not only on this particular method, but on all competitive measures which purport to be measuring competitive dominance. Only by studying these situations in terms of

their response requirements and generality will anything be discovered about social dominance if, in fact, such a concept is desirable. But one important principle has already been established, especially from the rat data: psychologists should not invoke a social concept merely because there are two animals in the apparatus.

FIGURE 6.1

The values of correlations calculated between successive blocks of individual and social drinking measures as indicated by weight gain.

(The following series of line graphs were adapted from Becker & Flaherty, 1968)

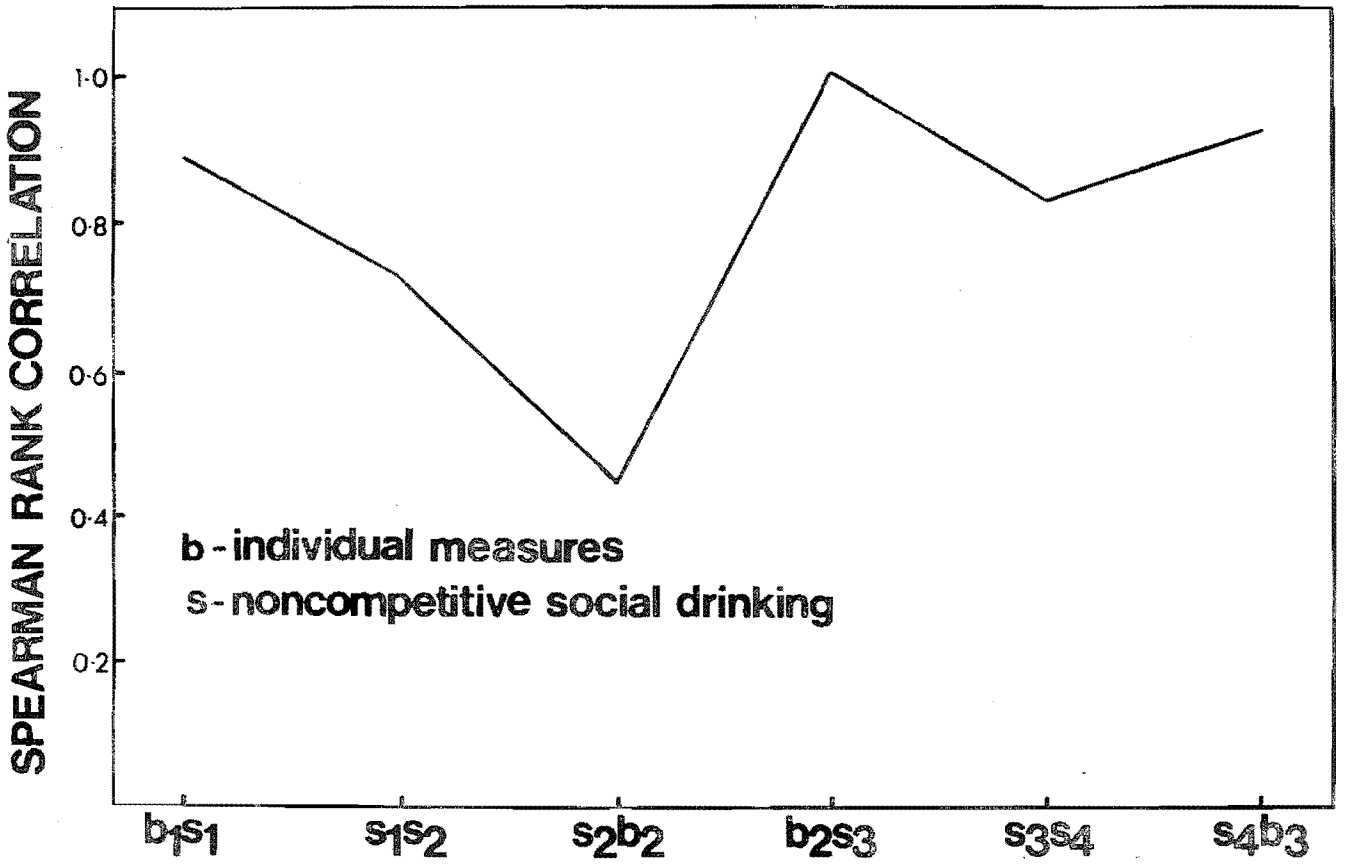


FIGURE 6.2

The values of correlations calculated between successive rounds of baseline measures with the drinking tube recessed in the competitive condition.

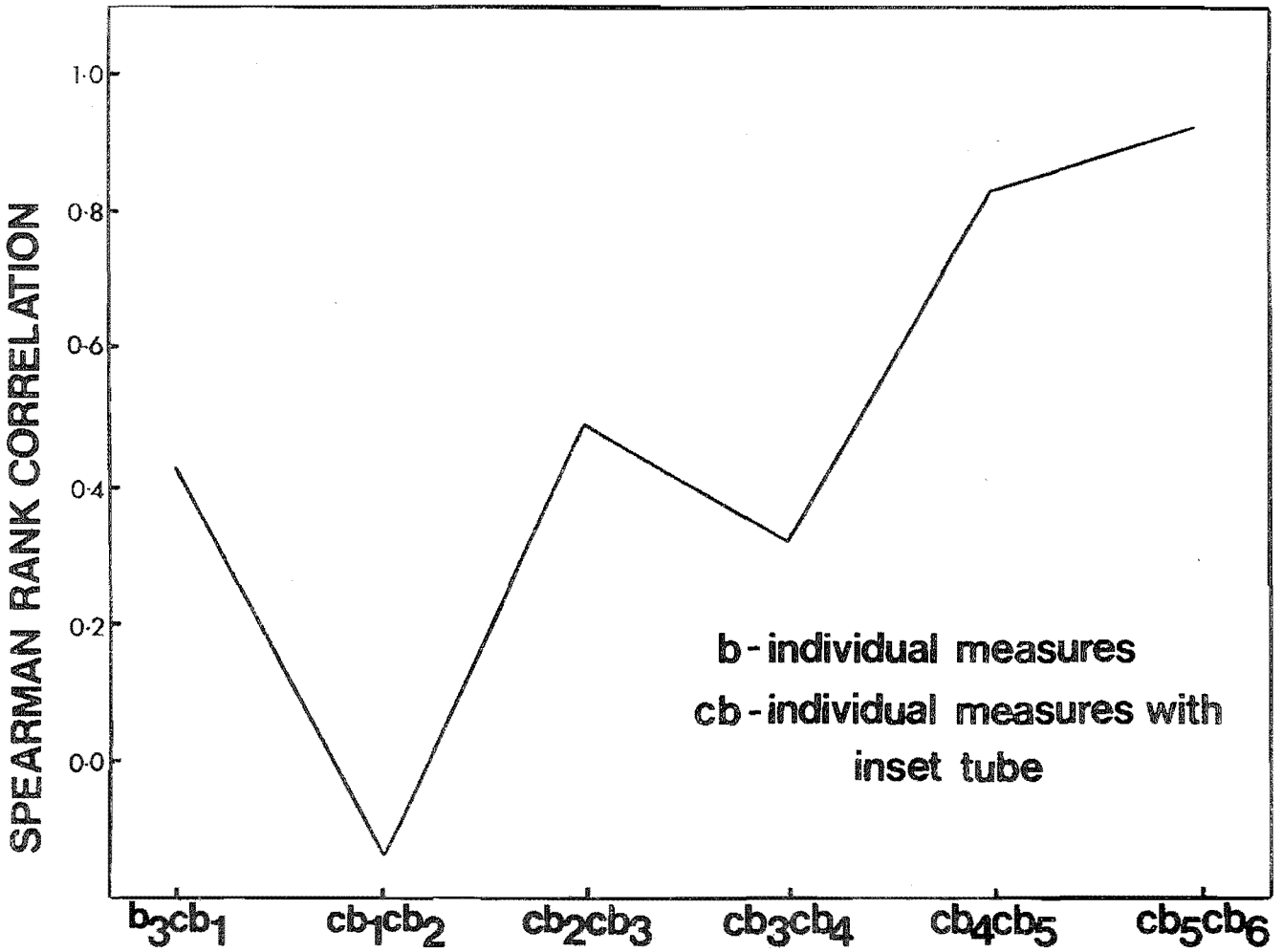


FIGURE 6.3

The values of correlations calculated between successive blocks of individual and competitive measures as indicated by total weight gain in the water test situation.

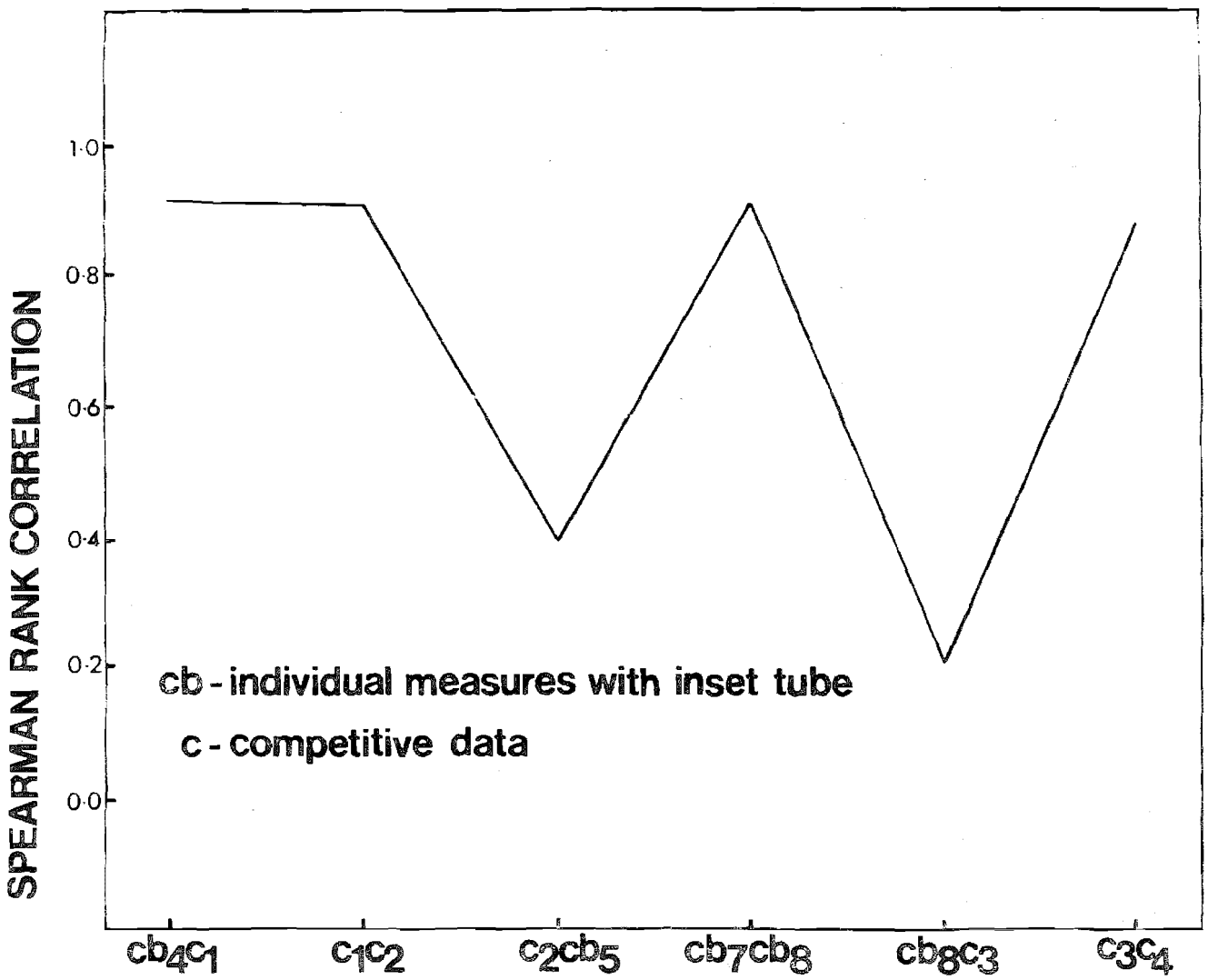


FIGURE 6.4

The values of correlations calculated between successive rounds of water competition for both total time and total weight measures.

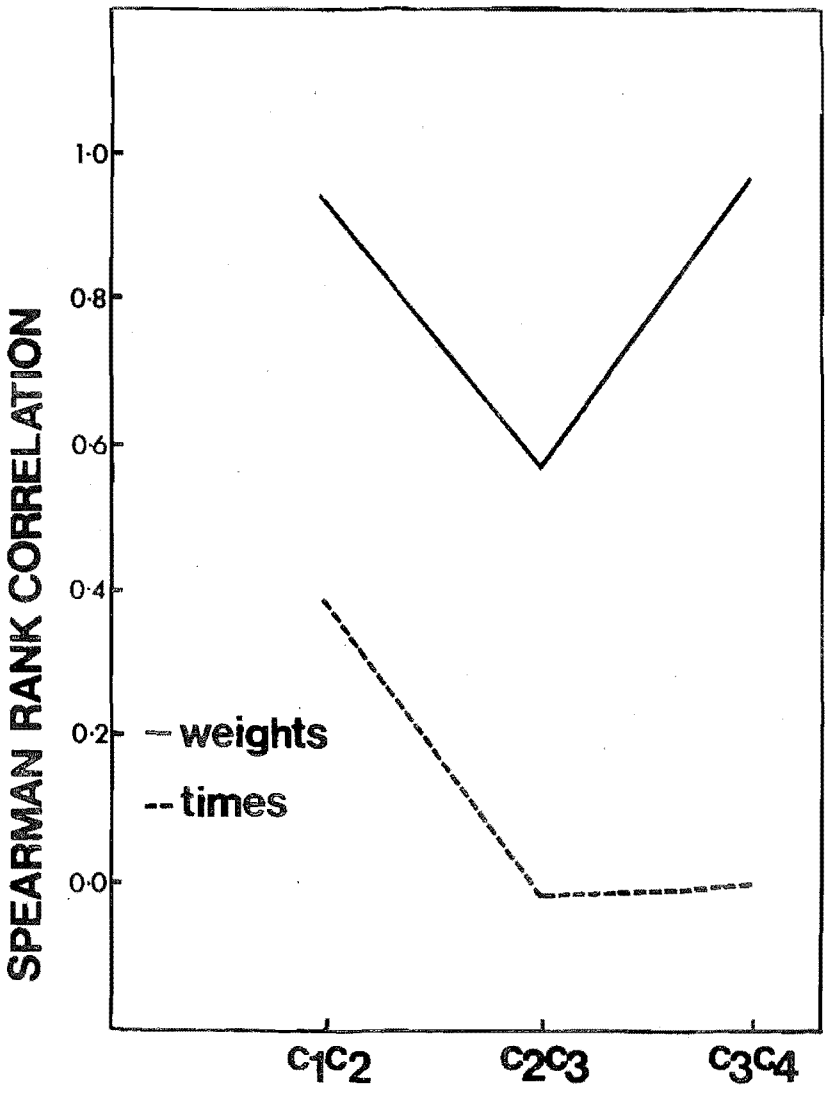


FIGURE 6.5

The values of correlations calculated between successive rounds of water competition for both proportional time and proportional weight gain measures.

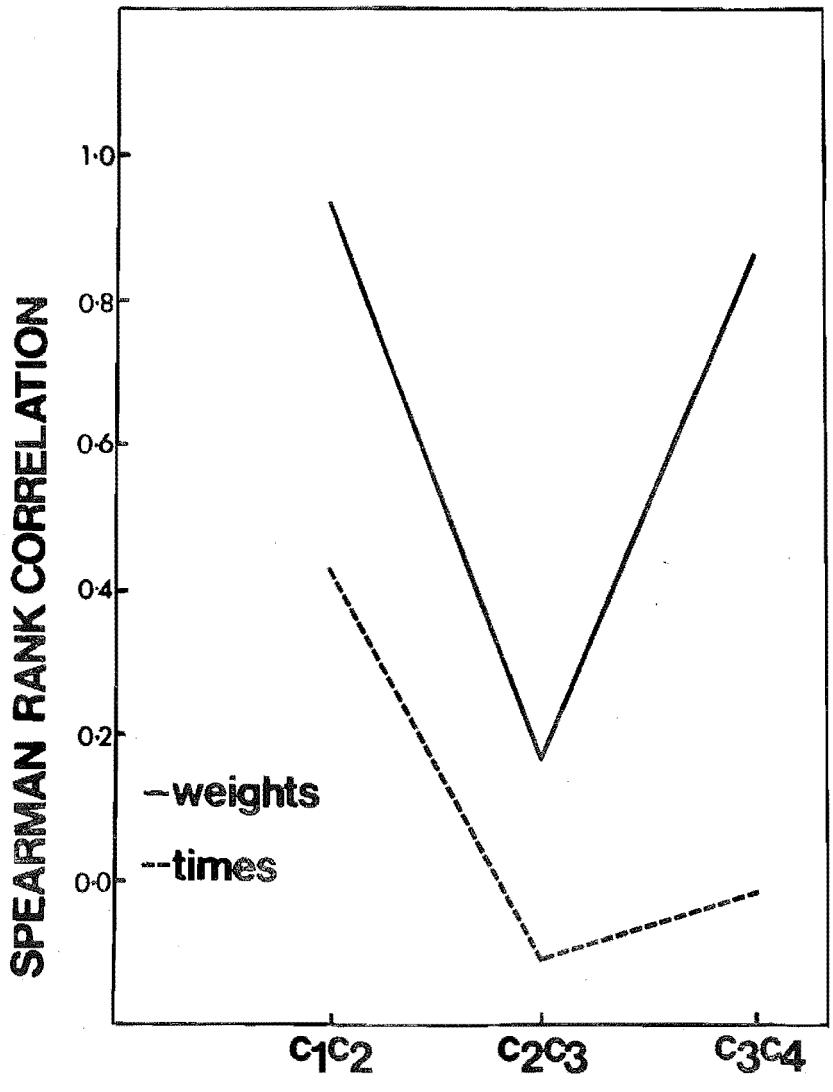


FIGURE 6.6

The values of correlations calculated between total times and total weight gain measures for the four rounds of water competition.

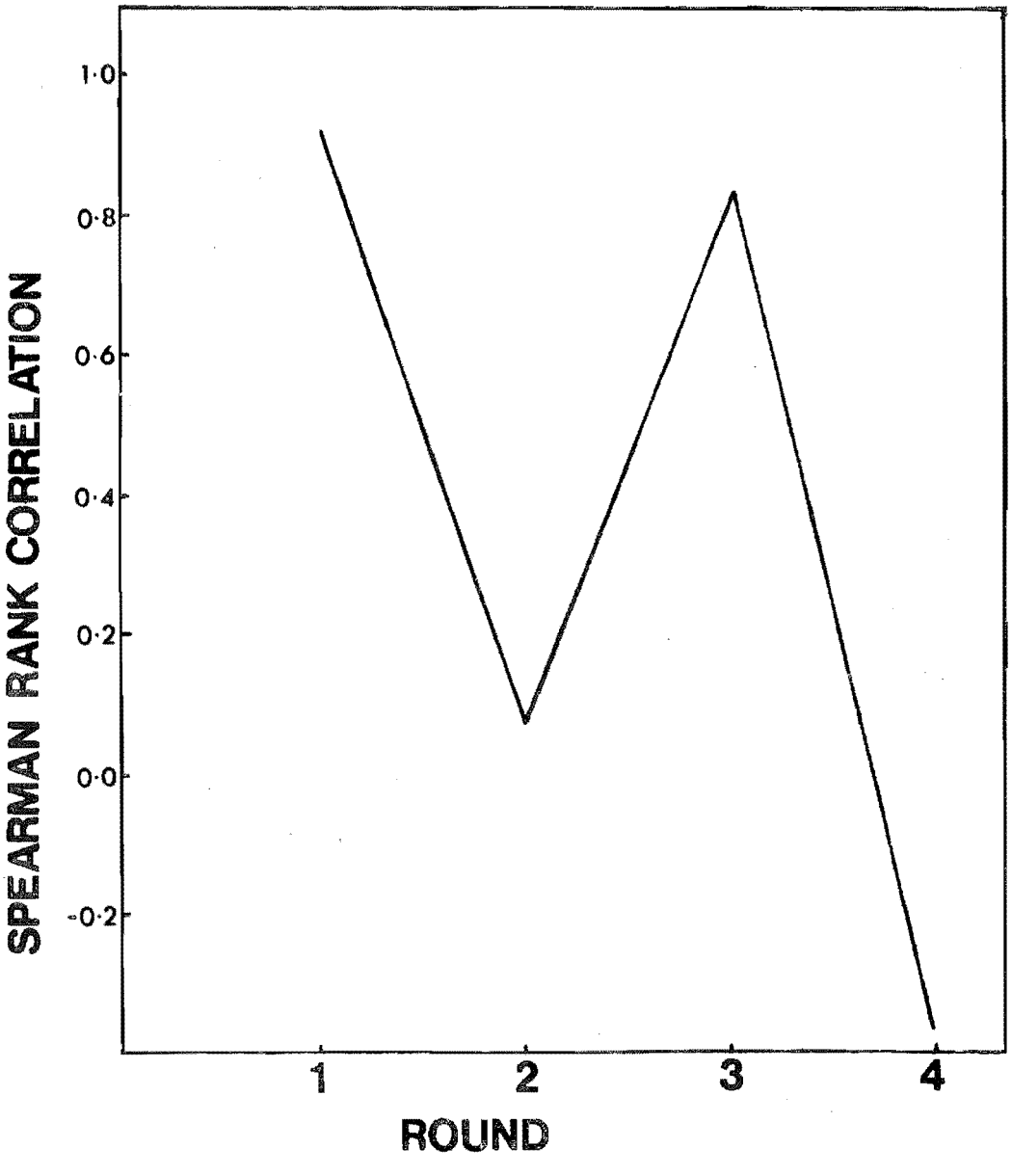


FIGURE 6.7

The values of correlations calculated between the weight gains from successive blocks of individual baseline measures in the eating situation.

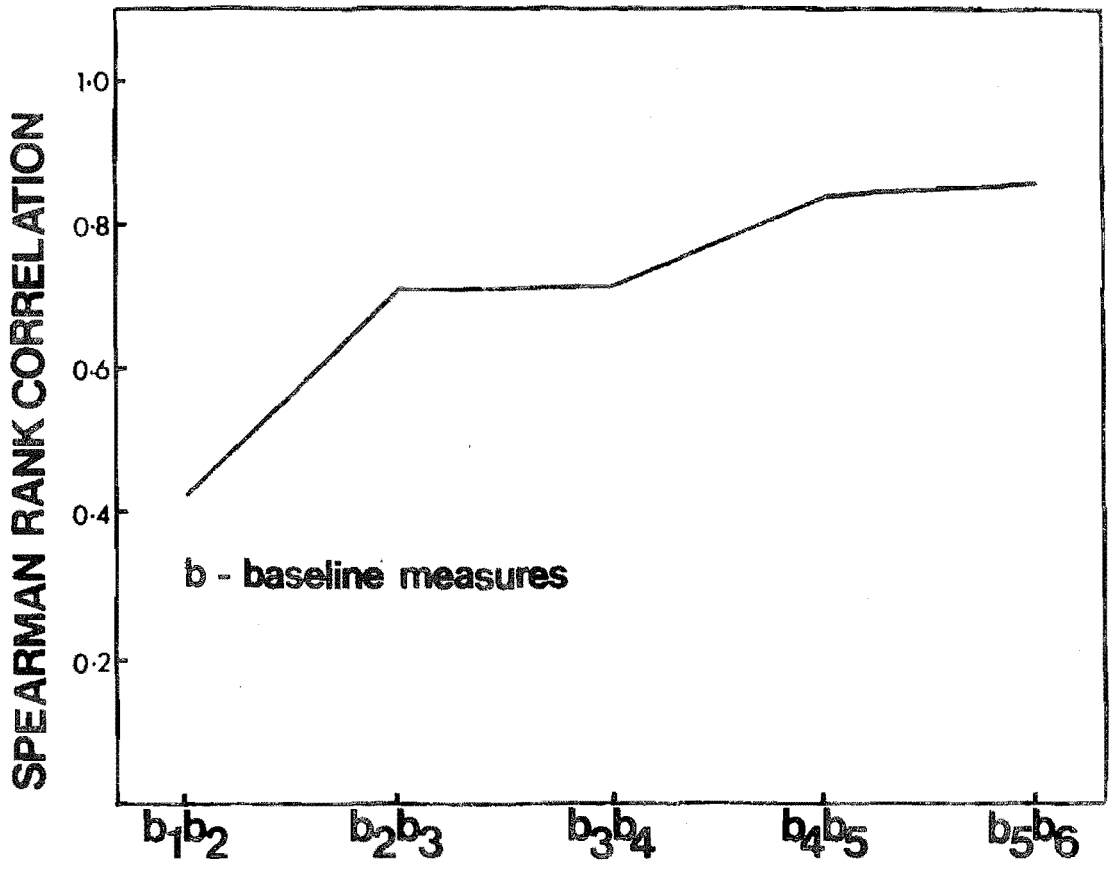


FIGURE 6.8

The values of correlations calculated between the weight gains from successive blocks of baseline and competitive baseline conditions, for the food competition group.

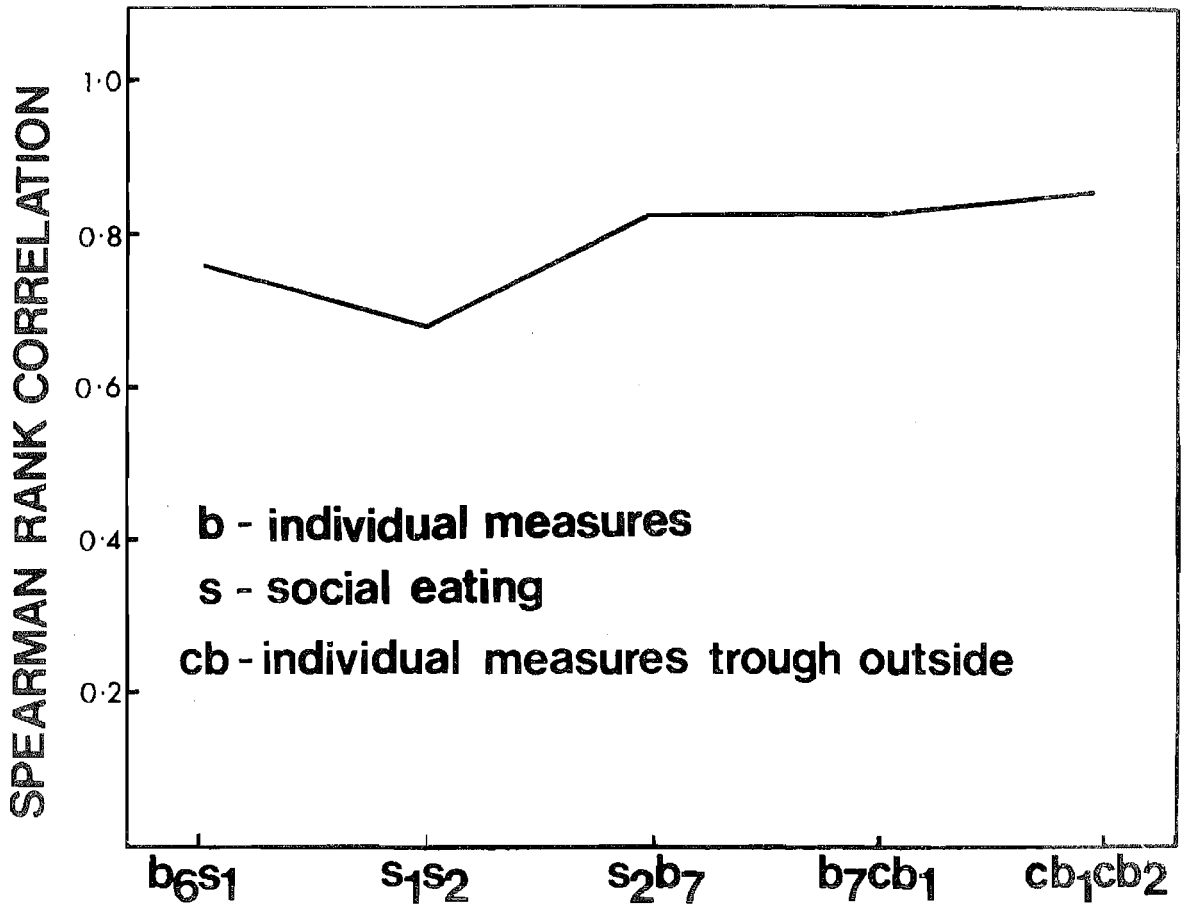


FIGURE 6.9

The values of correlations calculated between successive blocks of individual and competitive measures as indicated by weight gain in the food competition group.

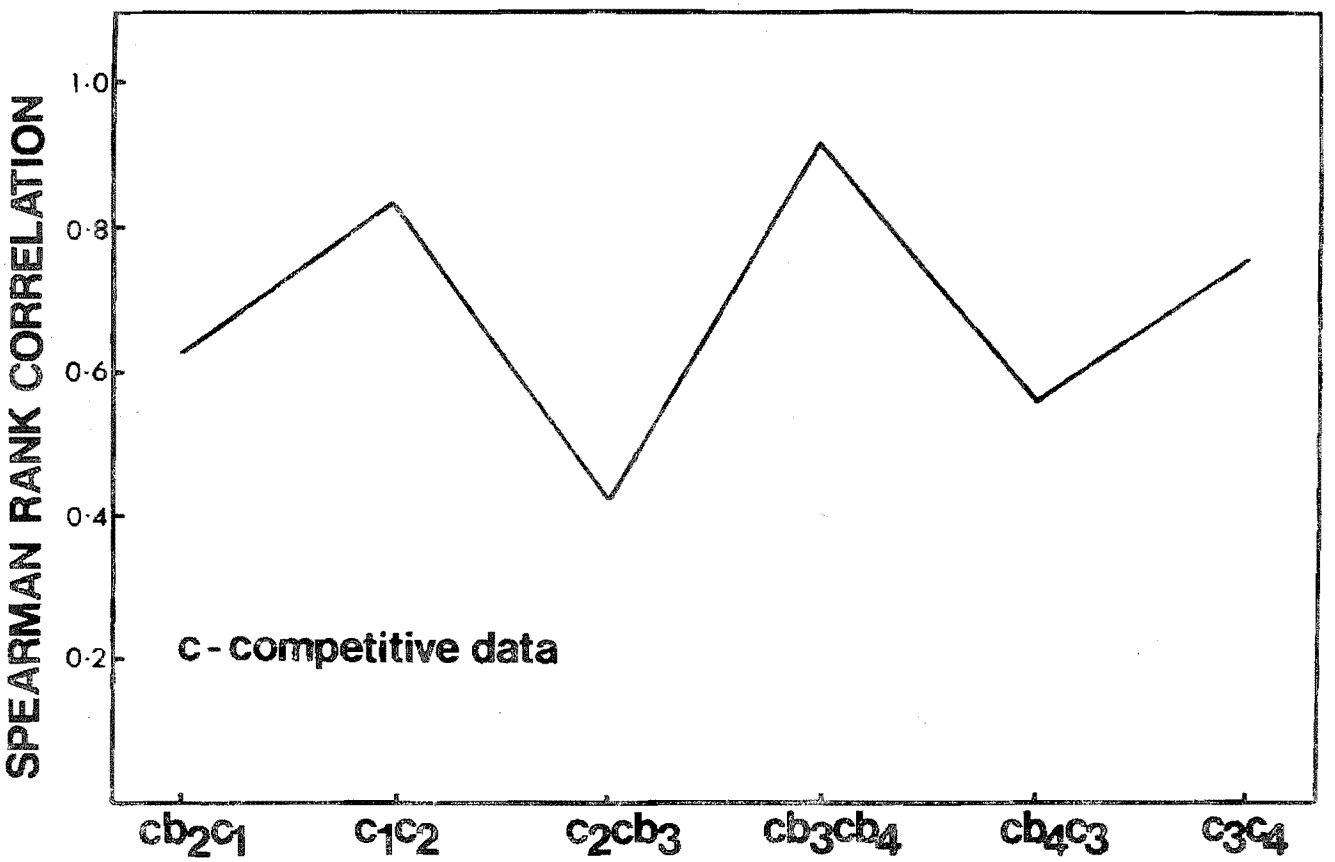


FIGURE 6.10

Values of correlation coefficients calculated between successive rounds of food competition for both total time and total weight gain measures.

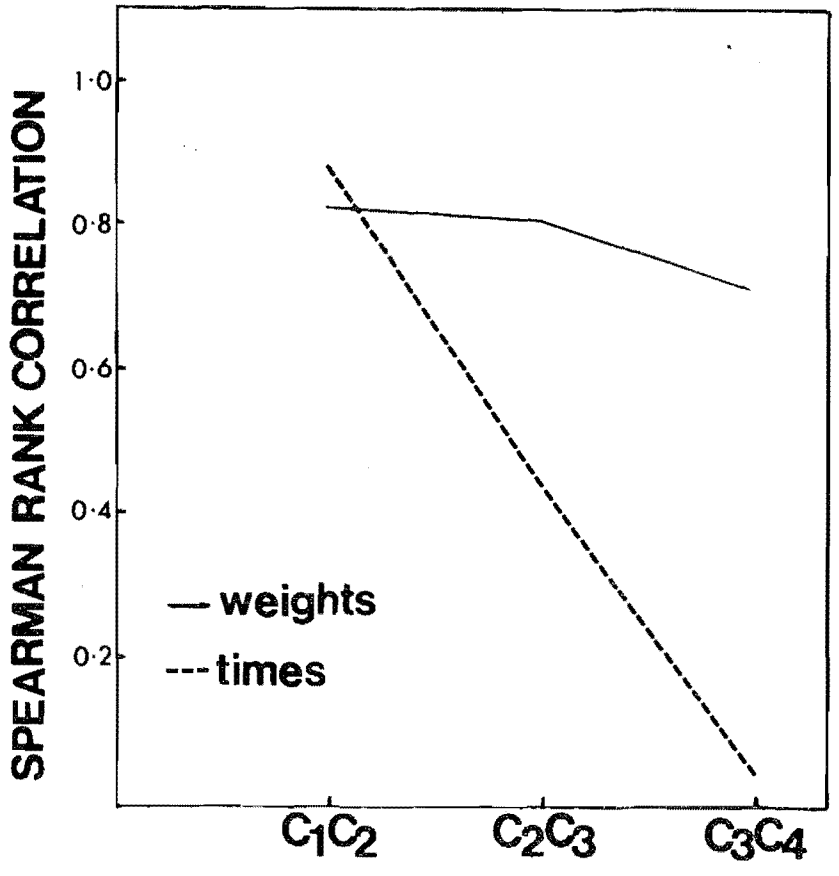


FIGURE 6.11

The values of correlation coefficients calculated between successive rounds of food competition for both proportional time and proportional weight gain measures.

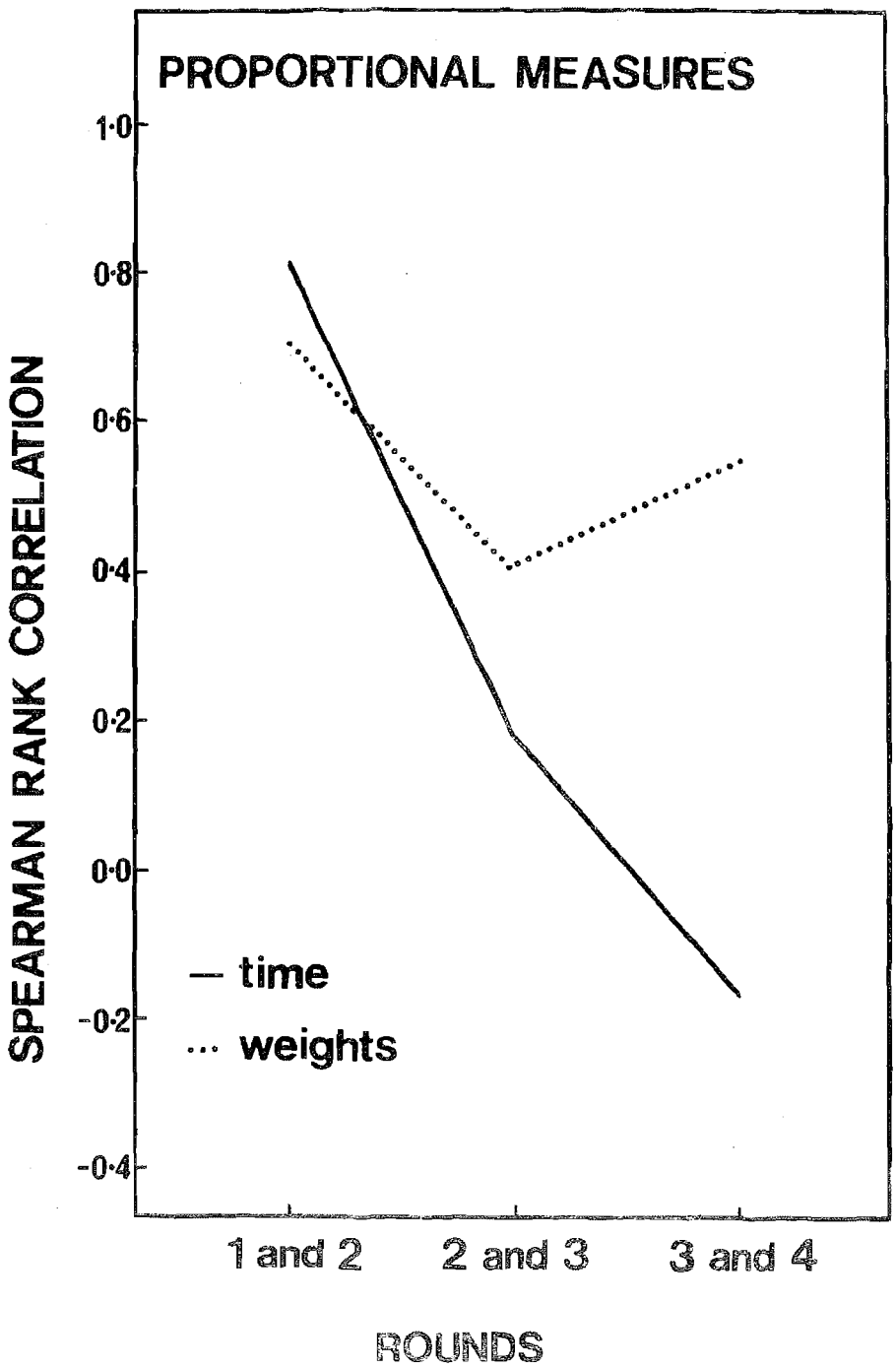


FIGURE 6.12

Correlations between the proportional and total times and proportional and total weight gains over the four rounds of food competition.

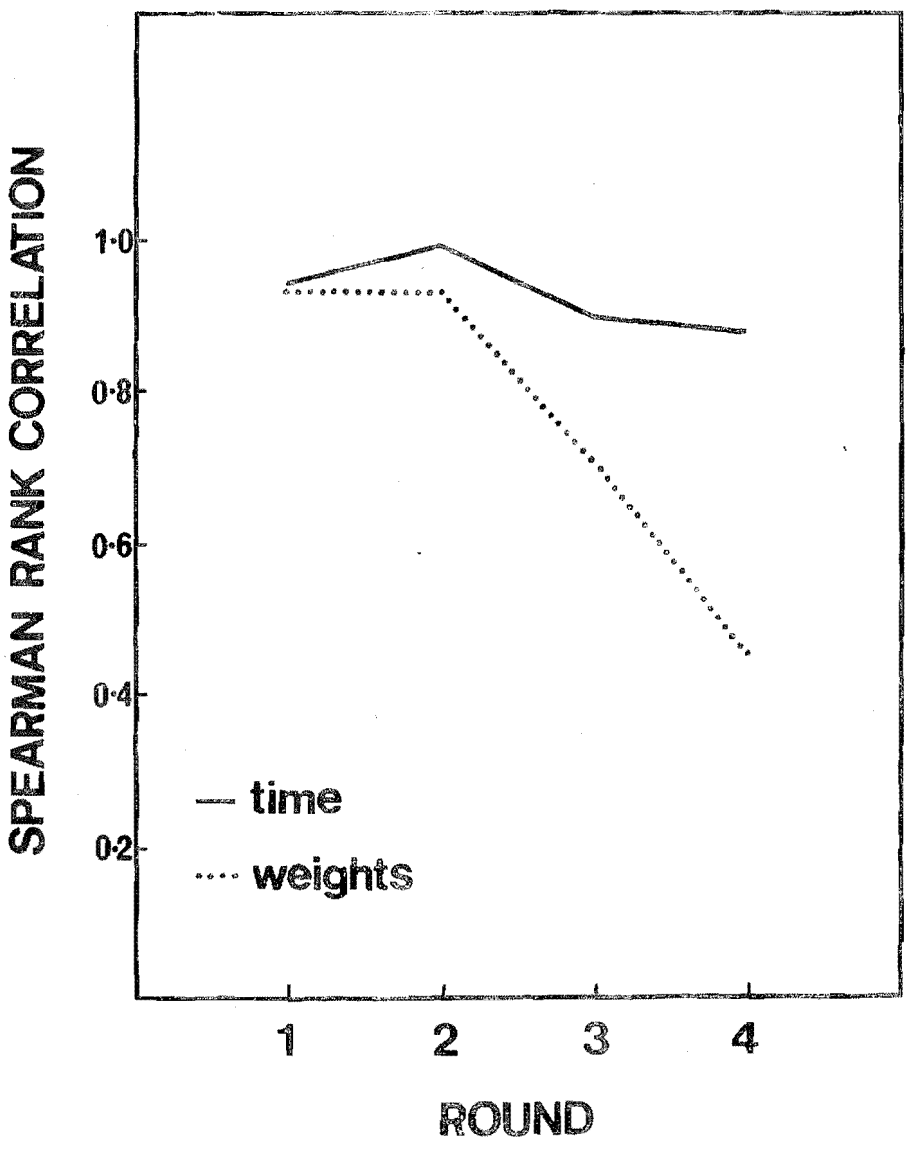


FIGURE 6.13

The values of correlations calculated between the total times and total weight gain measures for each round of food competition.

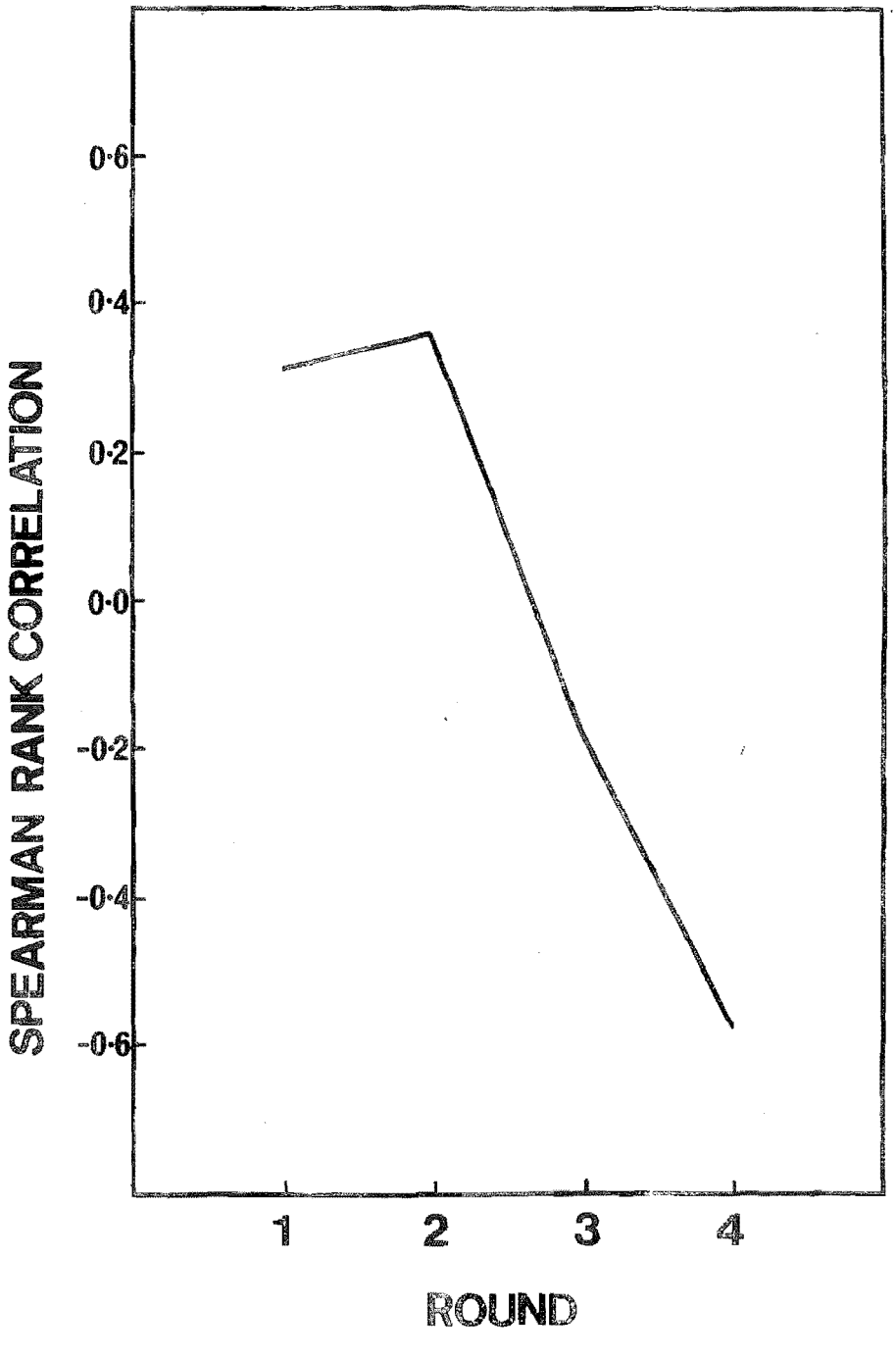


FIGURE 6.14

TOTAL TIMES

A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of competition.

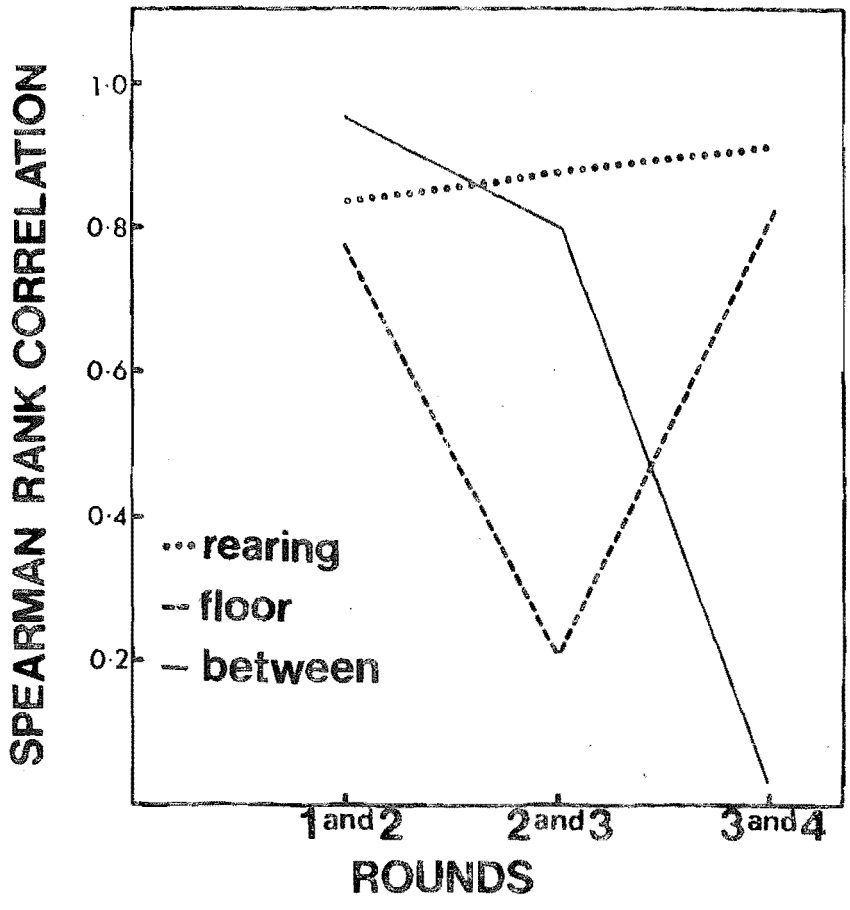


FIGURE 6.15

PROPORTIONAL TIMES

A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of water competition.

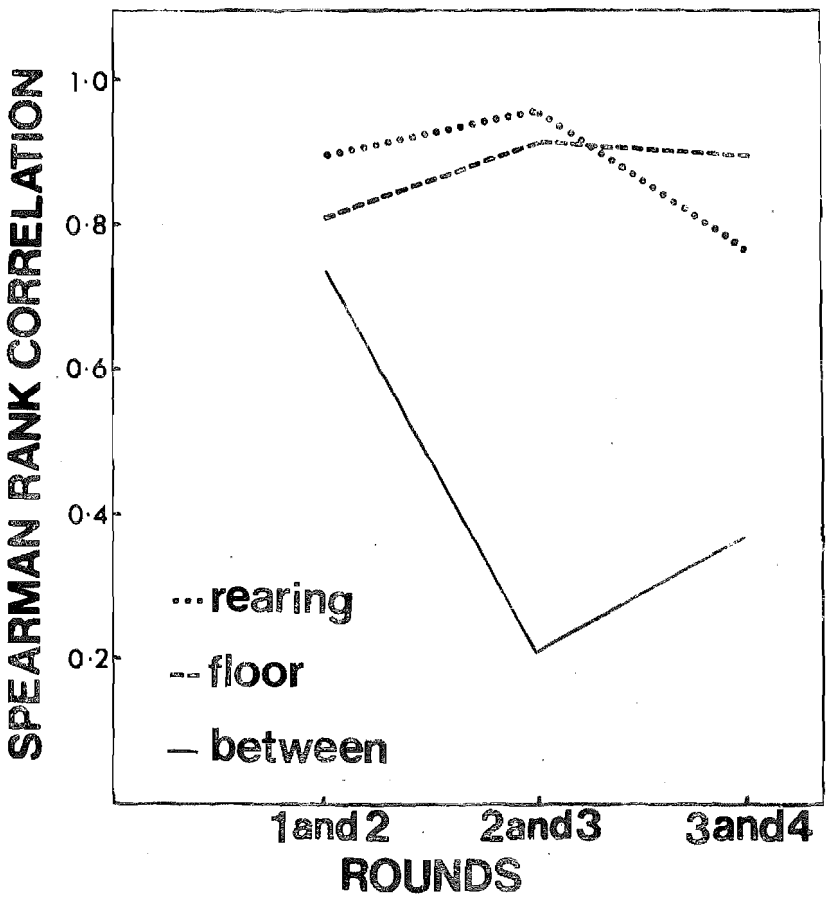


FIGURE 6.16

TOTAL WEIGHT GAIN

A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of water competition.

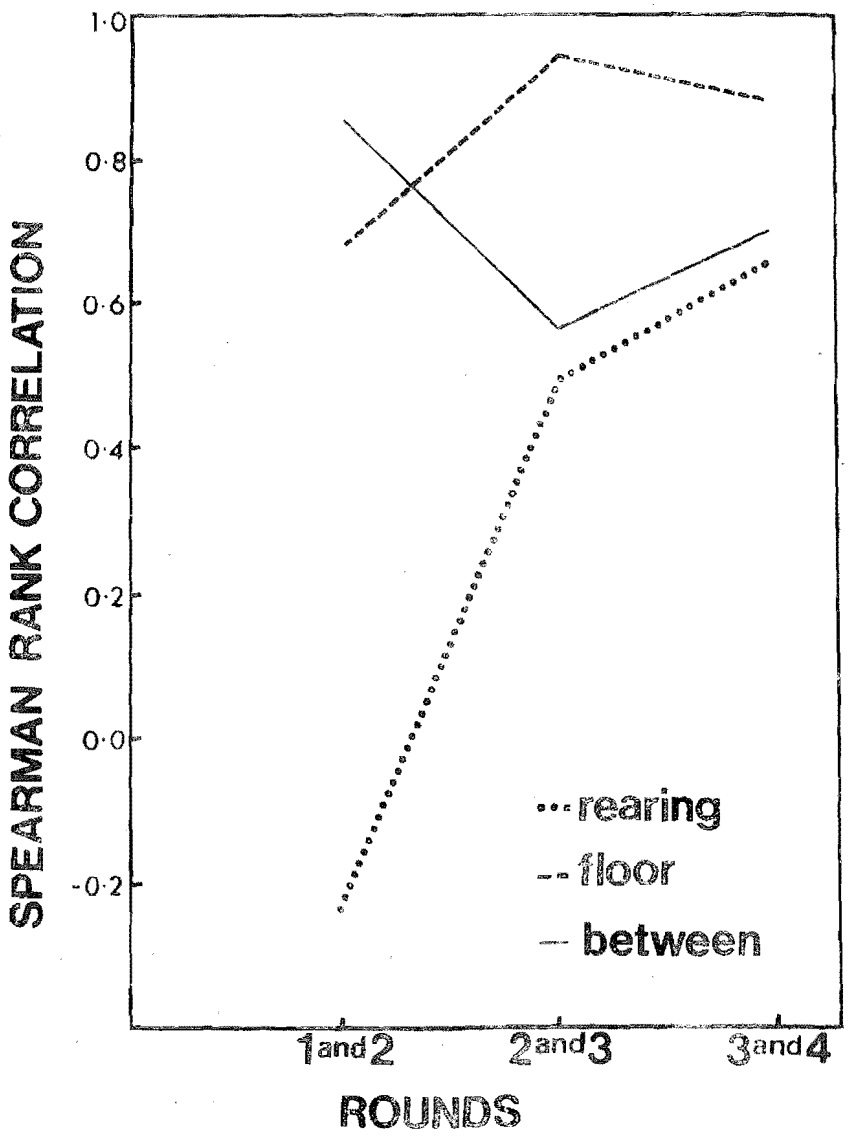


FIGURE 6.17

PROPORTIONAL WEIGHT GAINS

A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of water competition.

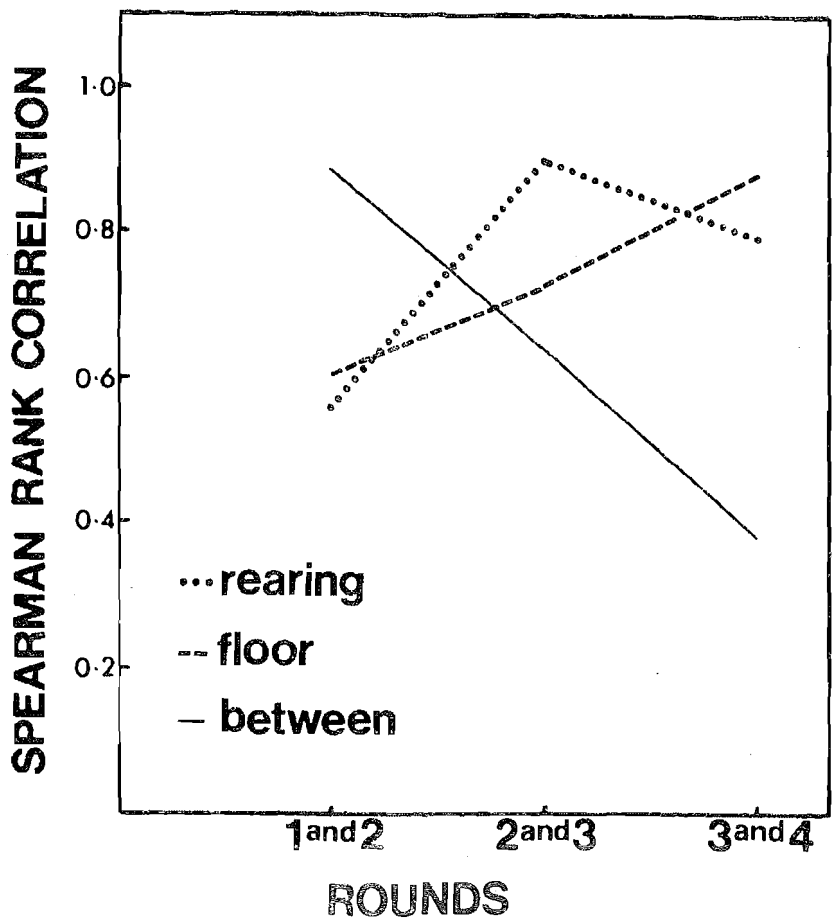


FIGURE 6.18

A diagrammatic representation of the "wedge" apparatus for measuring competitive orders in fowls. Scale: length of detention chamber = 0.73m, height = 1.2m, (----) = guillotine doors.

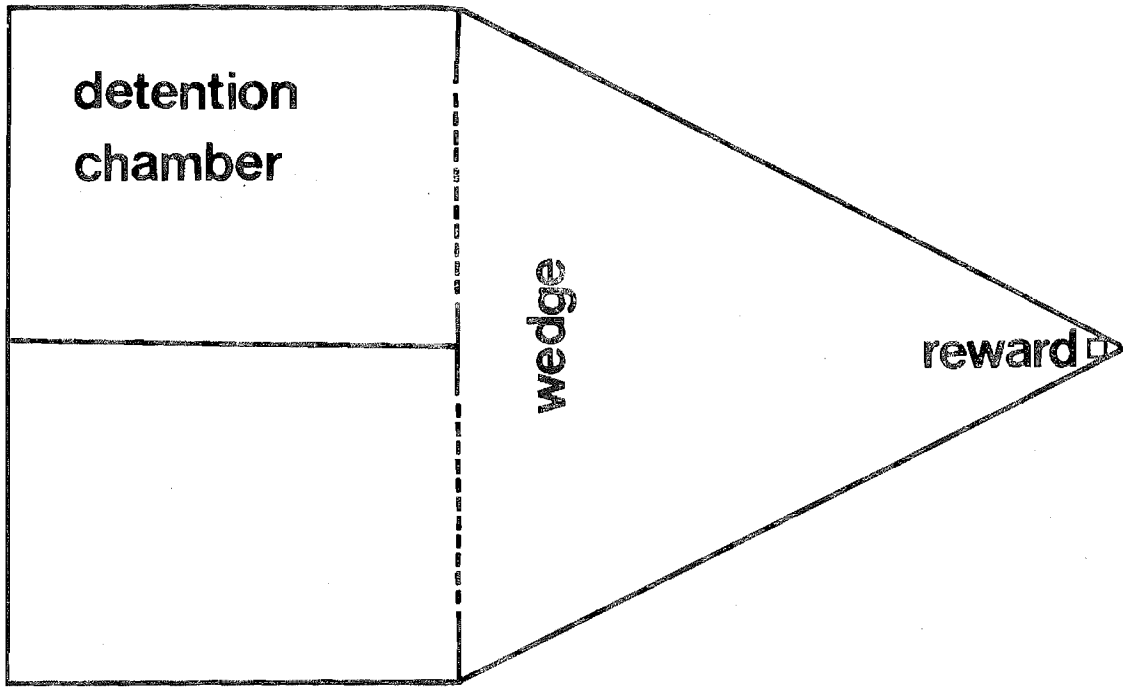


FIGURE 6.19

The values of correlations calculated between the two blocks of baseline measures on both competitive responses and the correlation between the two responses for the twelve days baseline for the three groups; rats (water), rats (food) and fowls.

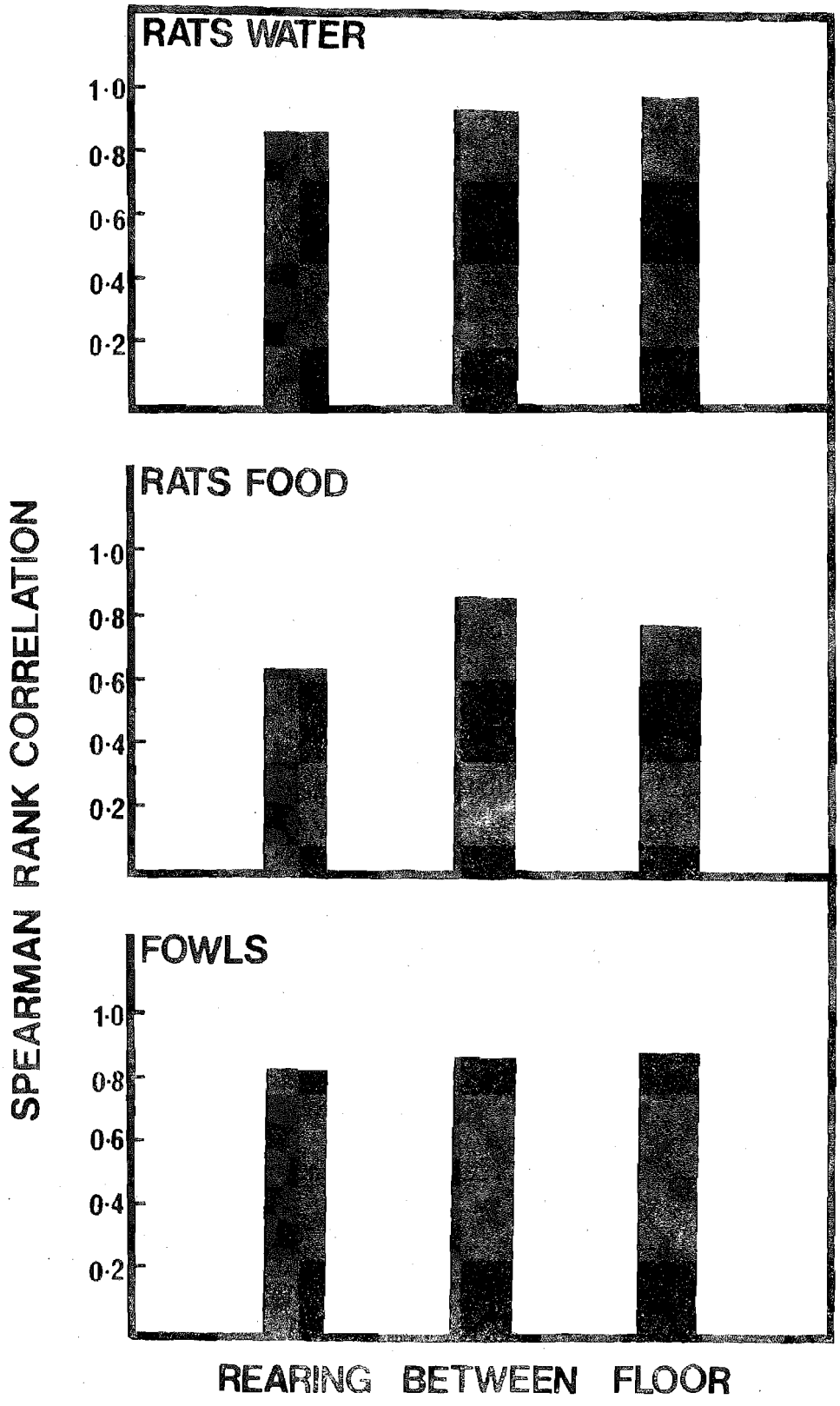


FIGURE 6.20

TOTAL TIMES - FOOD COMPETITION - RATS

A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of food competition.

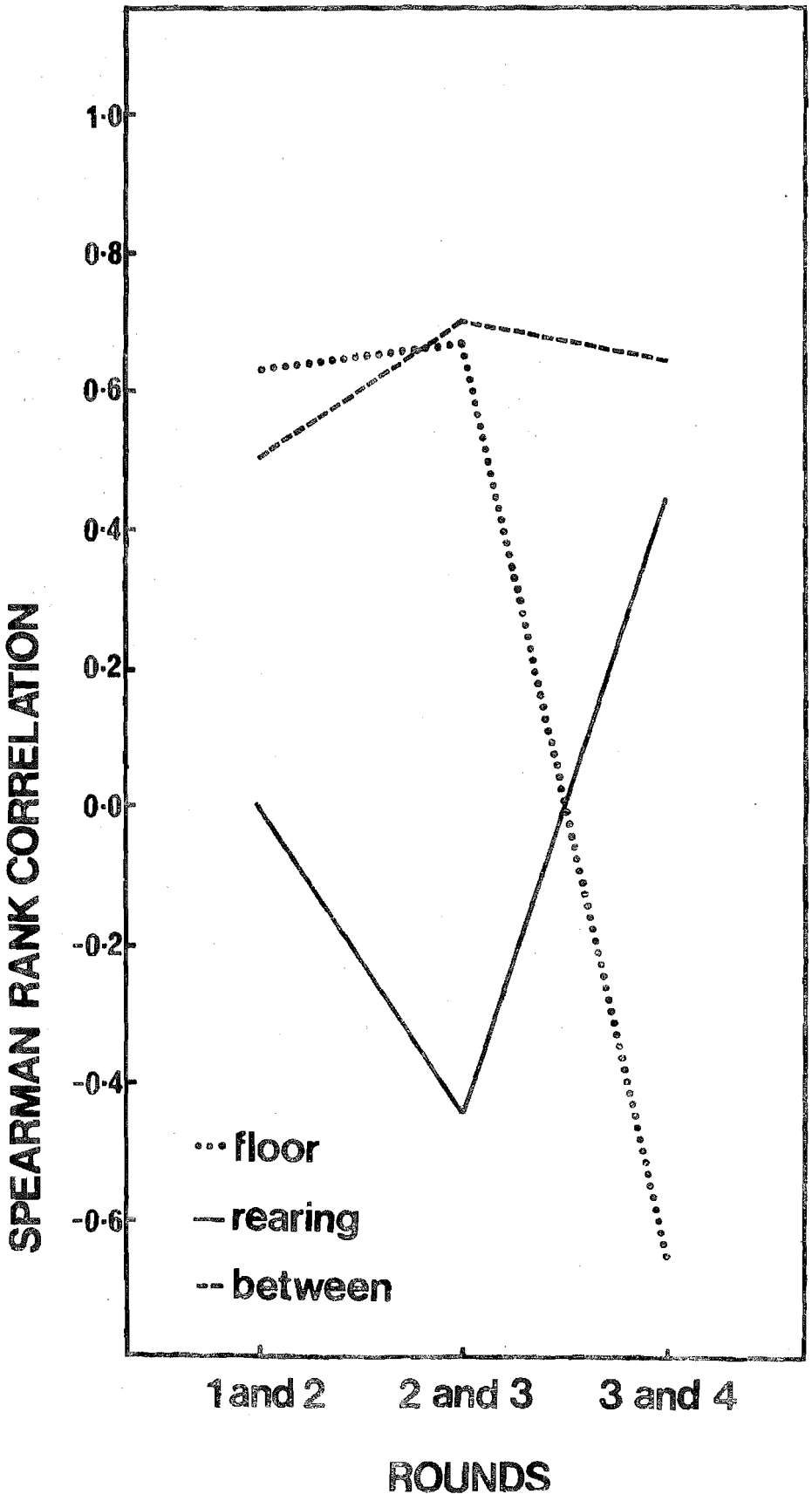


FIGURE 6.21

PROPORTIONAL TIMES - FOOD COMPETITION - RATS

A comparison of the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of food competition.

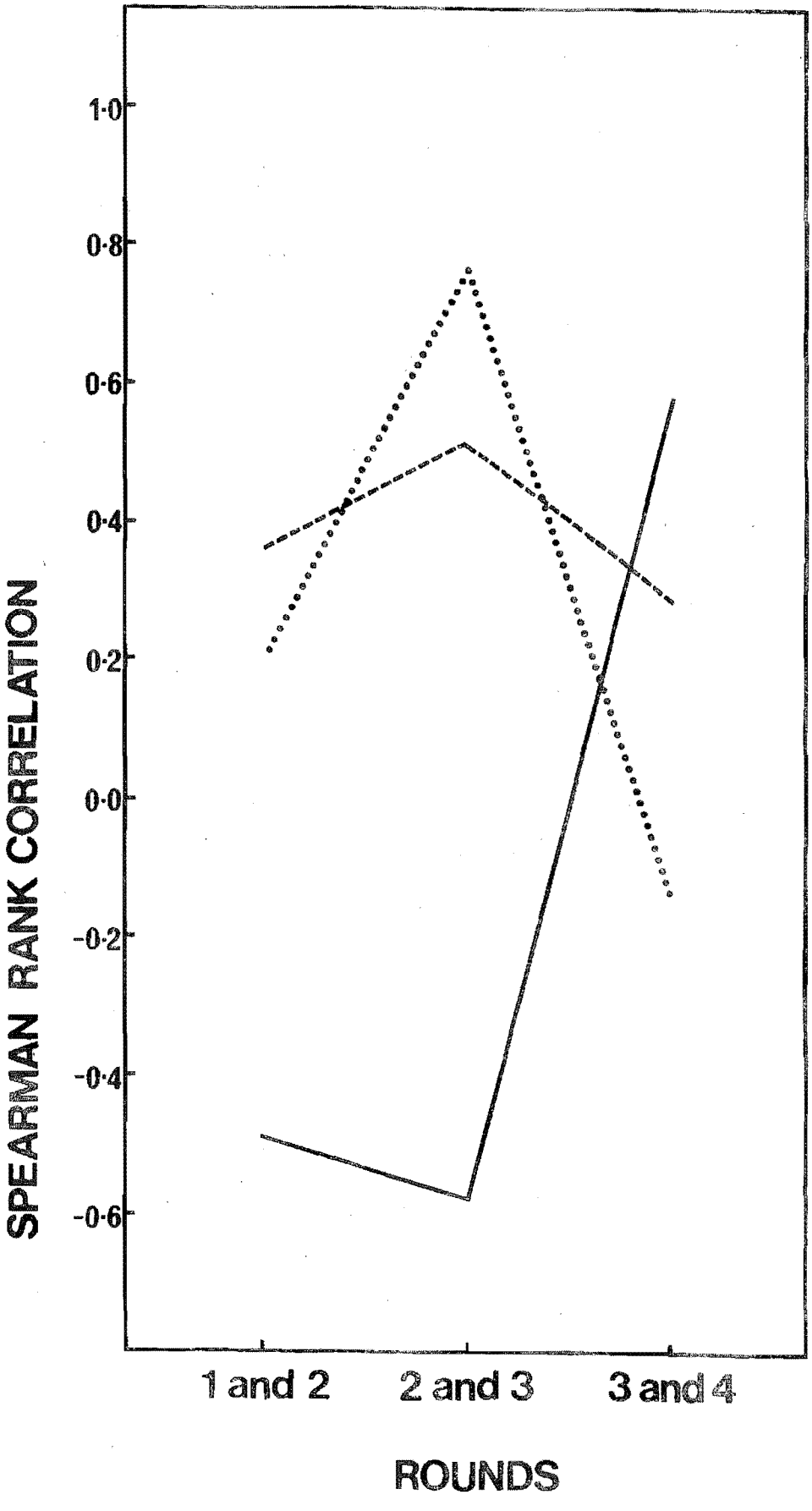


FIGURE 6.22

TOTAL TIMES - WATER COMPETITION - RATS A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of water competition.

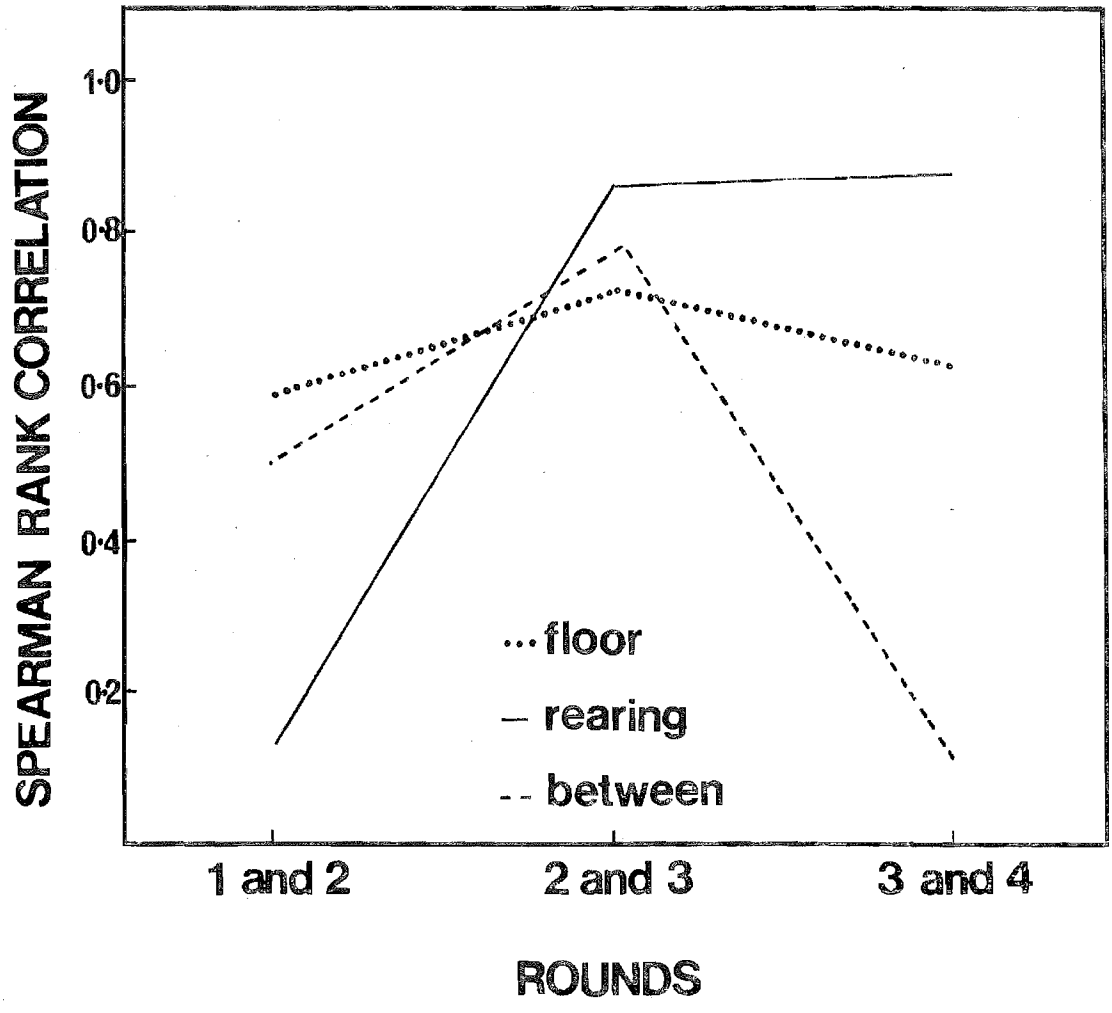


FIGURE 6.23

PROPORTIONAL TIMES - WATER COMPETITION - RATS
A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of water competition.

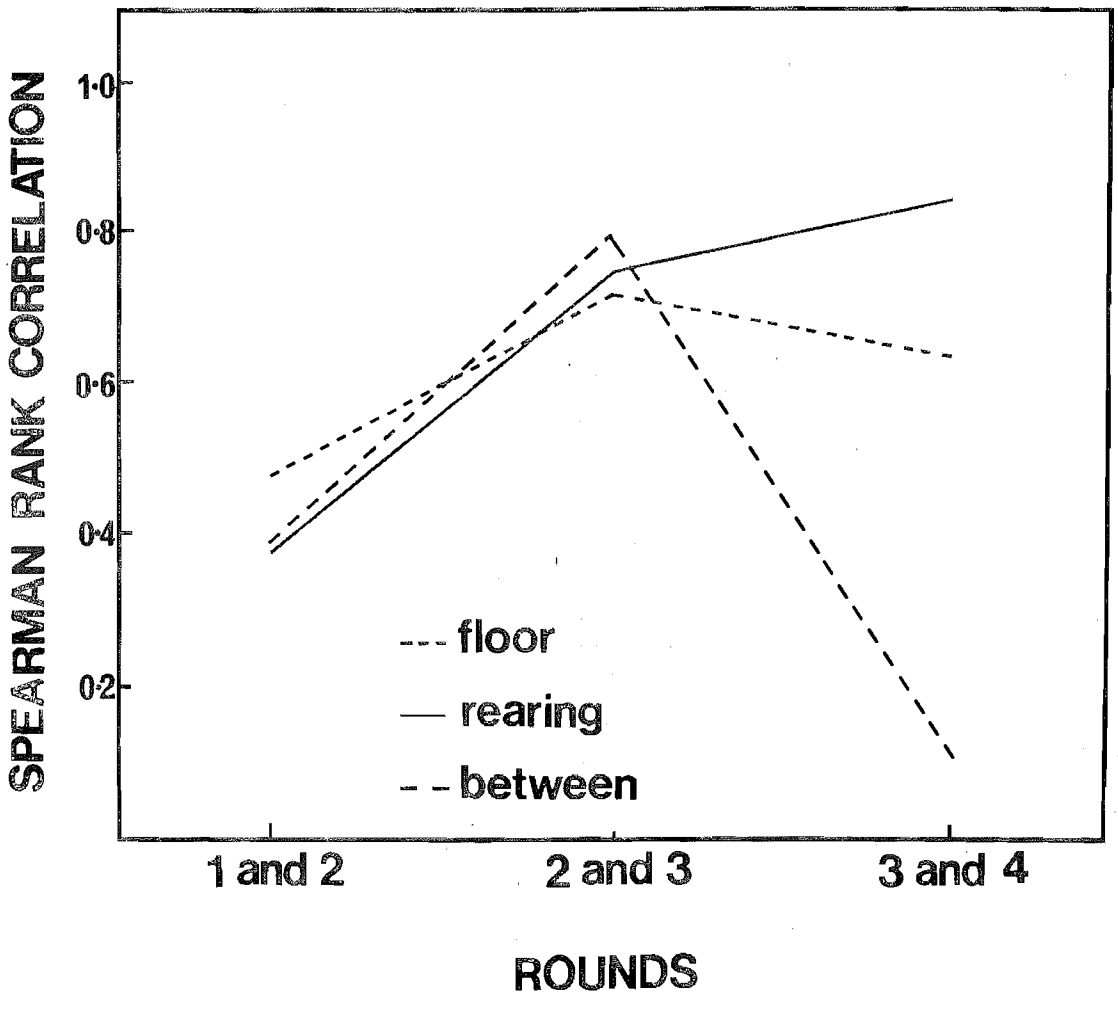


FIGURE 6.24

TOTAL TIMES - FOWLS

A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over four rounds of competition.

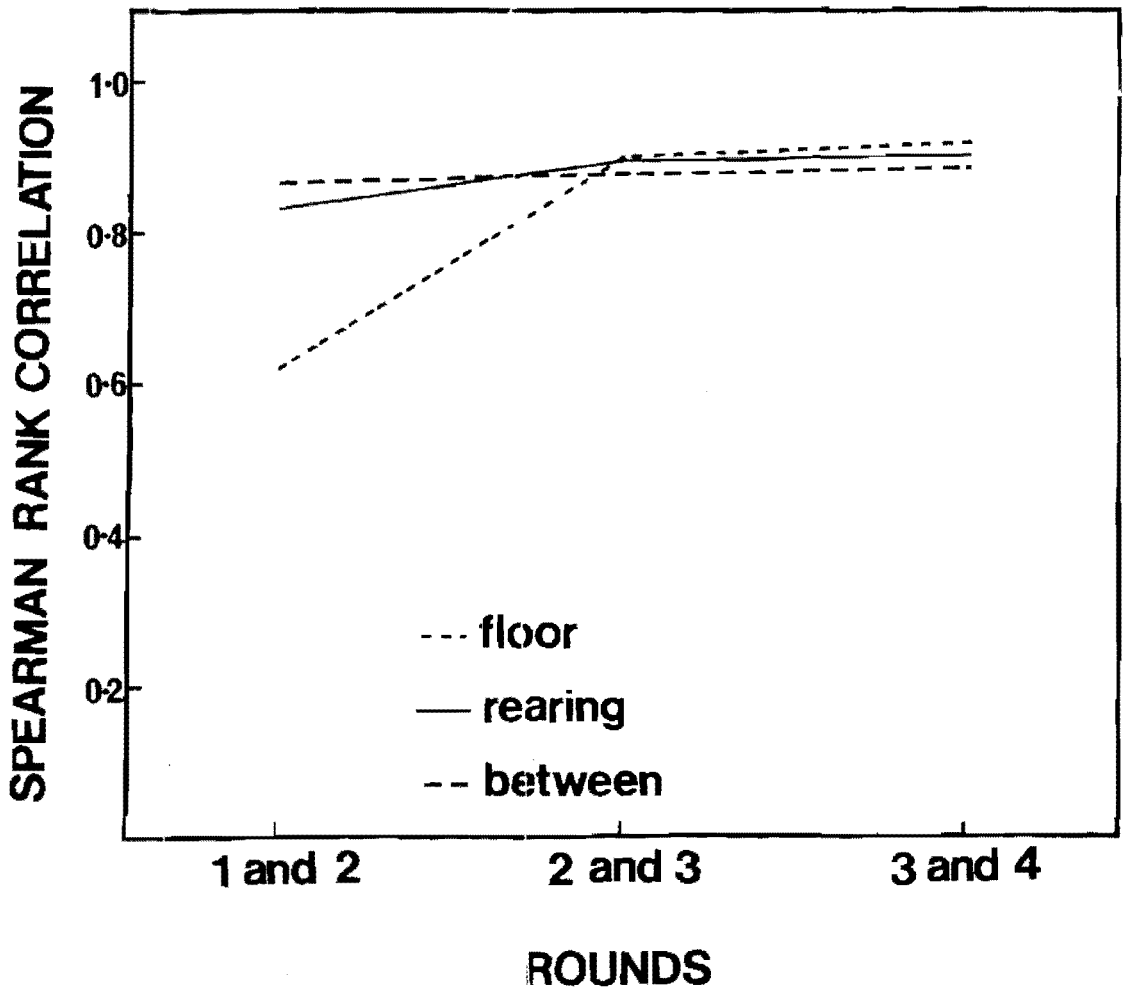


FIGURE 6.25

PROPORTIONAL TIMES - FOWLS A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of competition.

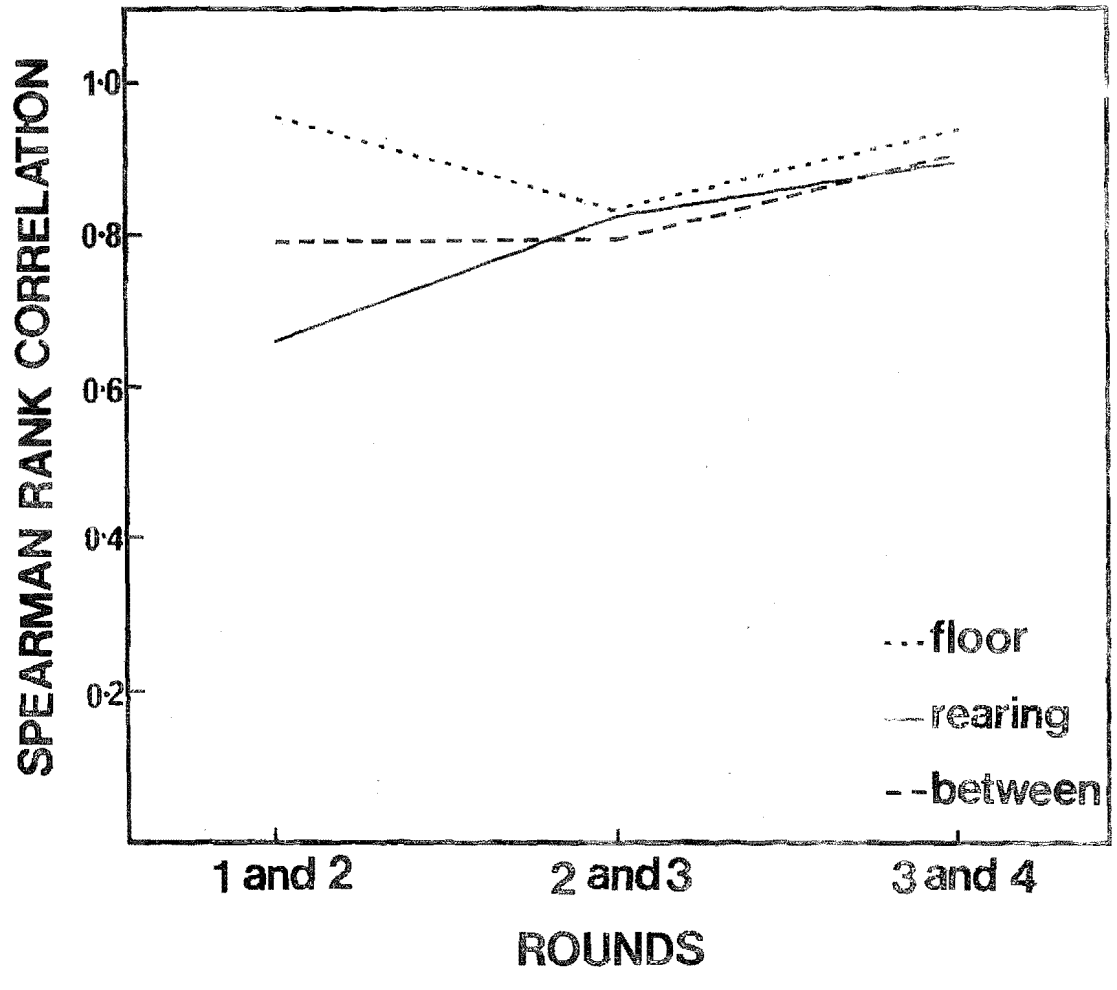


FIGURE 6.26

TOTAL WEIGHT GAINS - FOOD COMPETITION - RATS

A comparison between the reliabilities of competitive orders for each response and the correlation between the two competitive responses over the four rounds of competition.

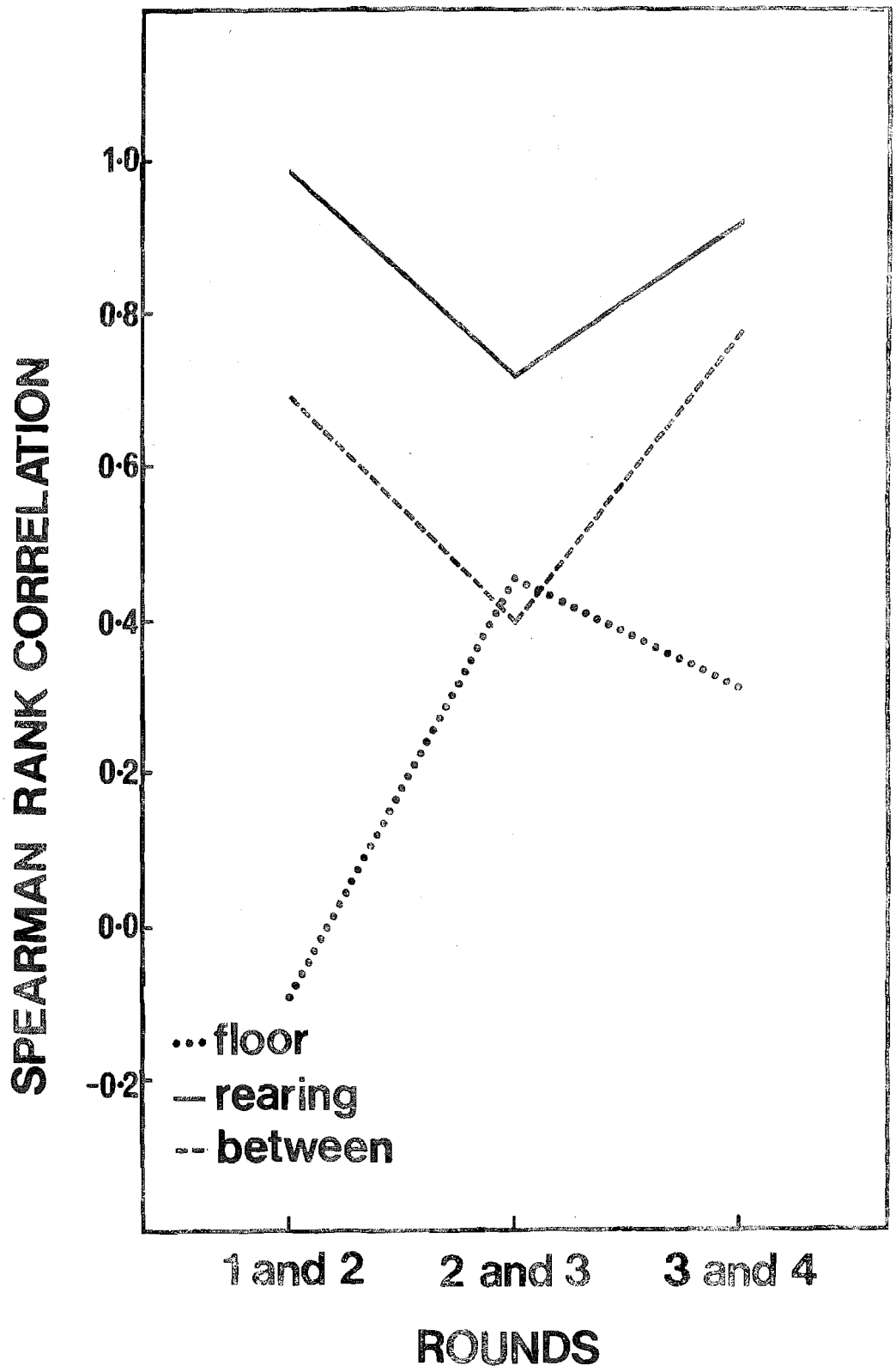


FIGURE 6.27

PROPORTIONAL WEIGHTS - FOOD COMPETITION - RATS
A comparison between the reliabilities of competitive orders for each response and the correlation between the two competitive responses over the four rounds of competition.

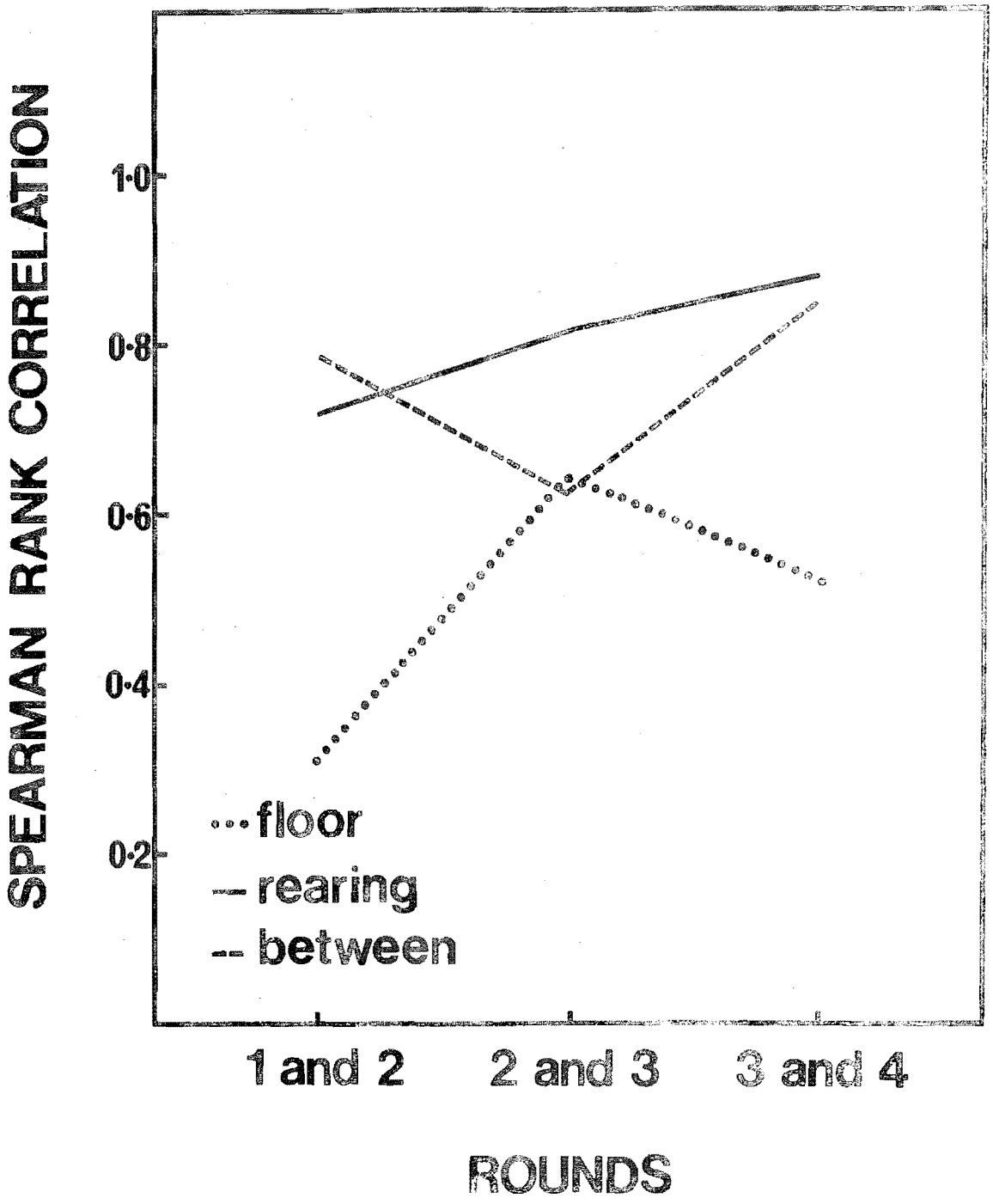


FIGURE 6.28

TOTAL WEIGHTS - WATER COMPETITION - RATS A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of competition.

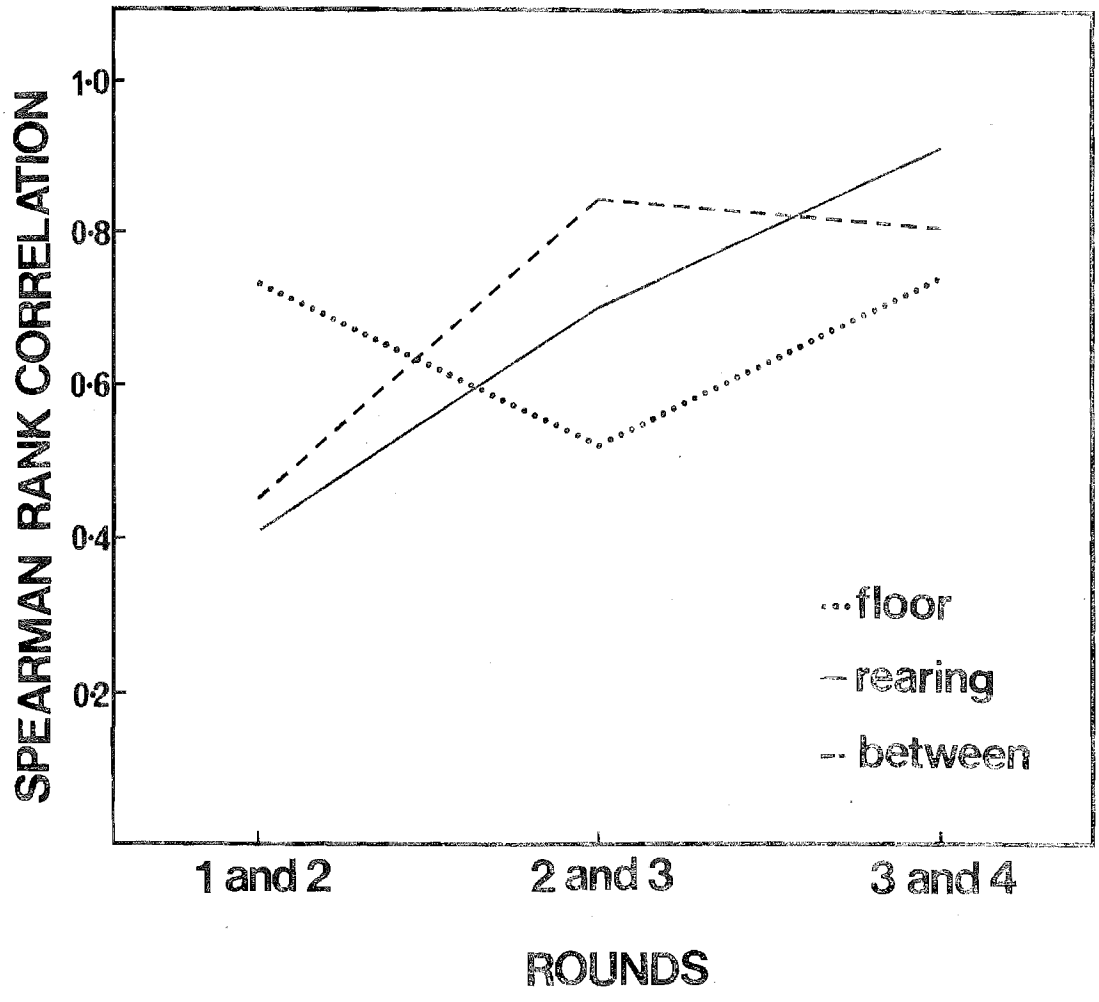


FIGURE 6.29

PROPORTIONAL WEIGHTS - WATER COMPETITION - RATS
A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of competition.

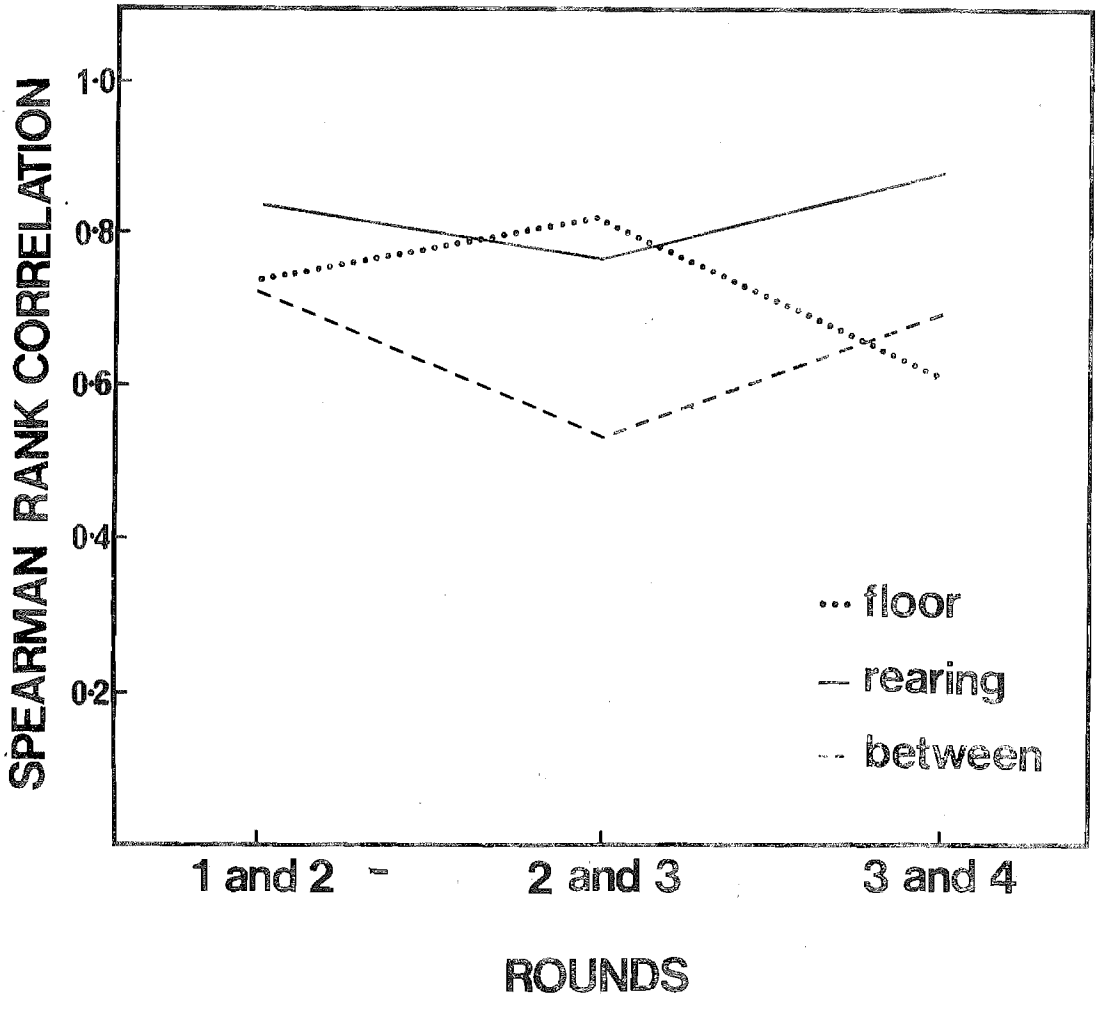


FIGURE 6.30

TOTAL WEIGHTS - FOWLS

A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of competition.

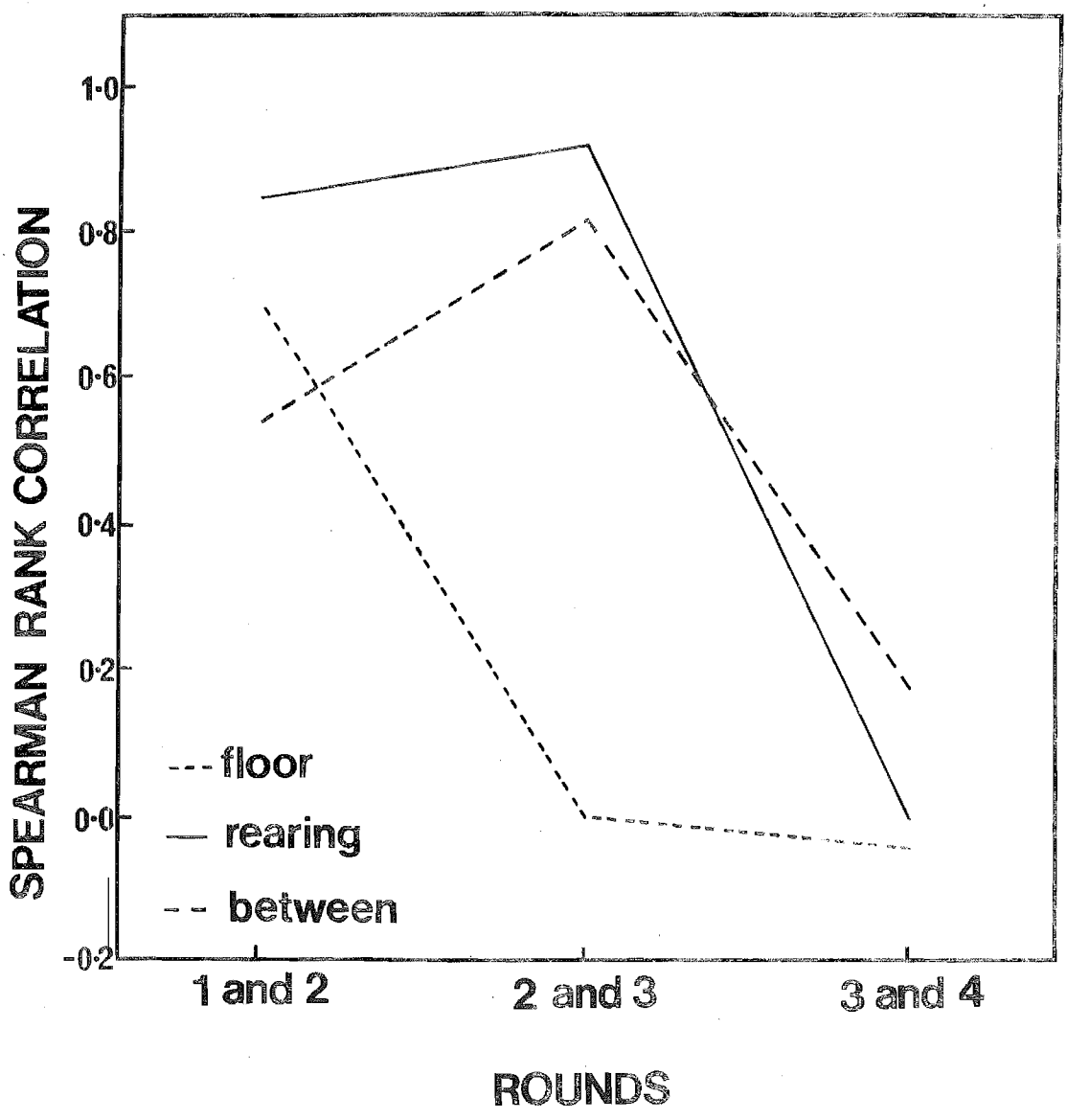


FIGURE 6.31

PROPORTIONAL WEIGHTS - FOWLS A comparison between the reliabilities of the competitive orders for each response and the correlation between the two competitive responses over the four rounds of competition.

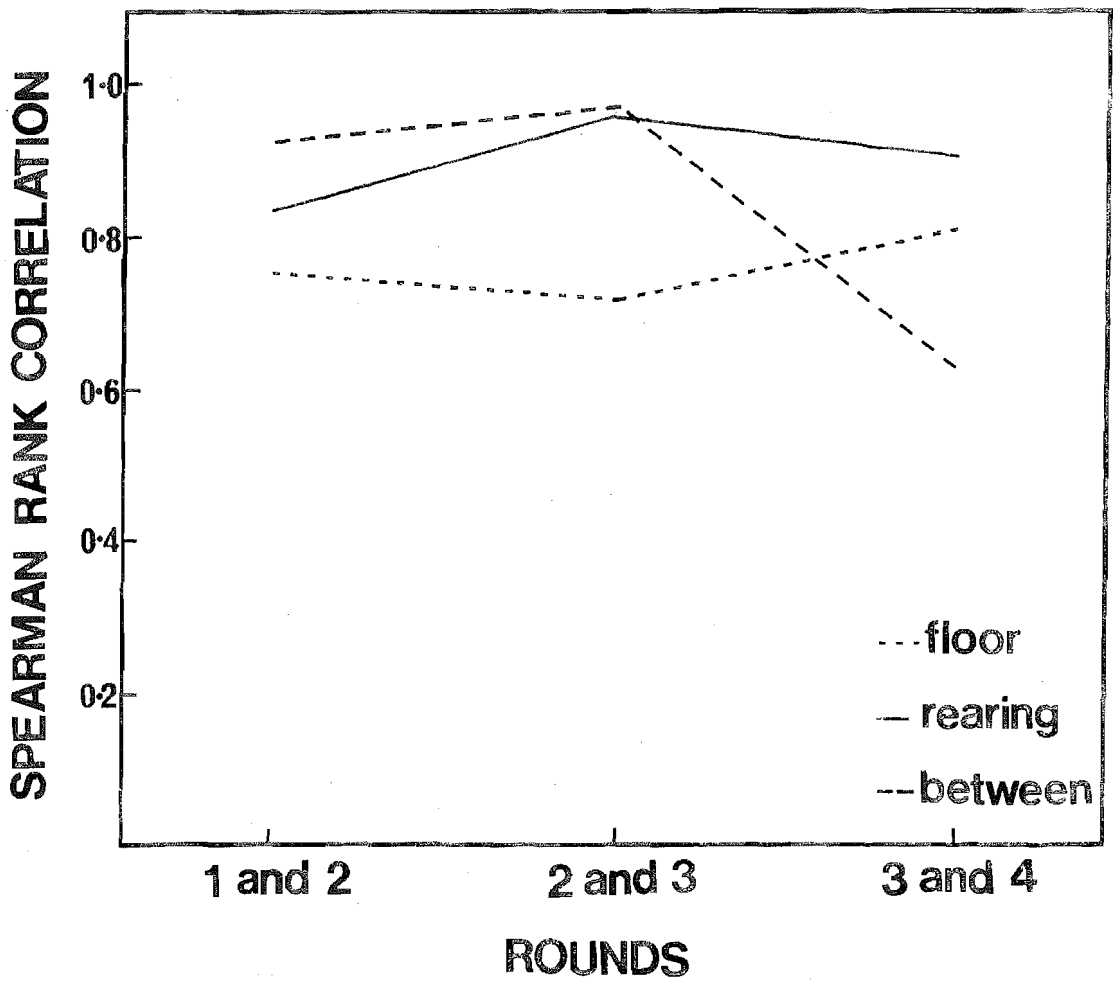


FIGURE 6.32

The values of correlations calculated between the proportional times and proportional weight gain measures for all three experimental groups. These were calculated from the combined data from both floor and rearing responses for each round.

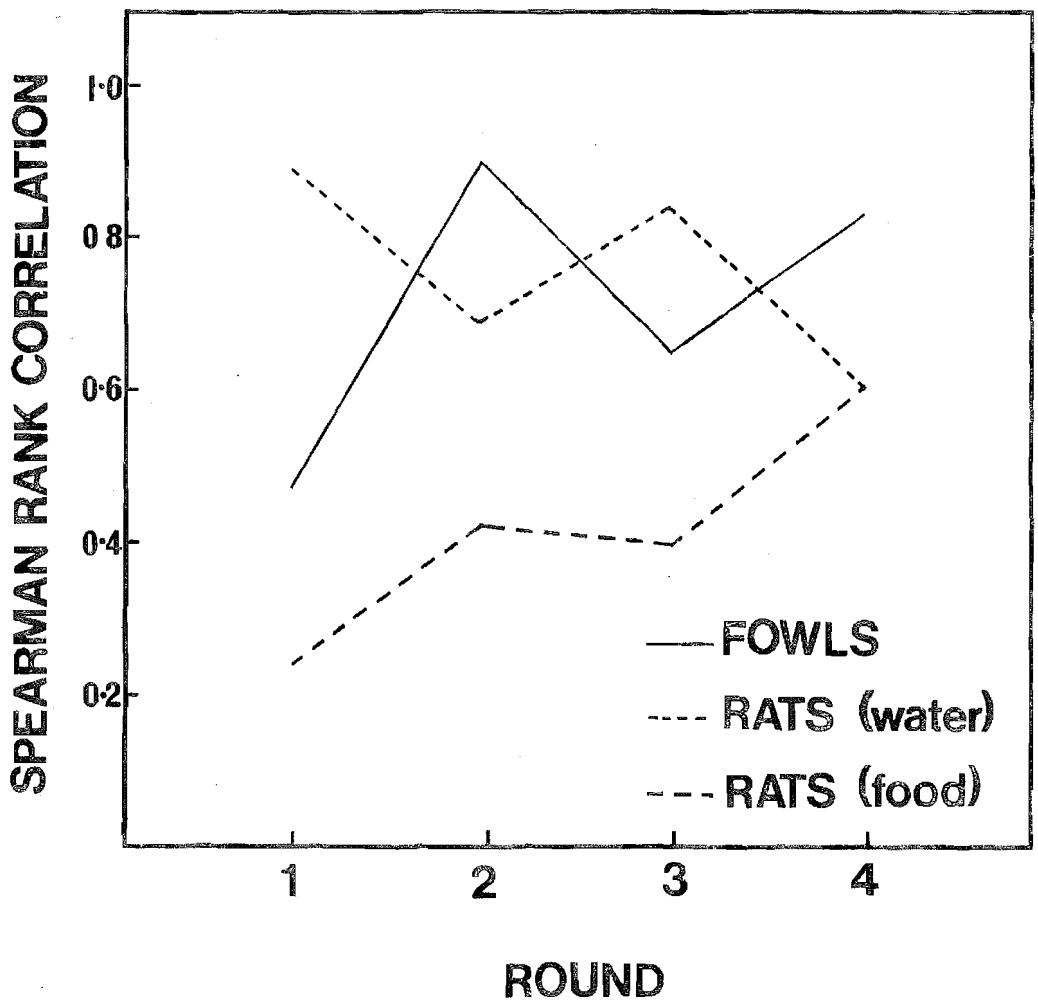


TABLE 6.1

Coefficients of concordance calculated for time and weight measures during a four minute period.

	Block 1	Block 2
Times	0.29	0.45^{++}
Weights	0.39^{+}	0.70^{++}

+ : $p < 0.05$

++ : $p < 0.01$

TABLE 6.2

Coefficients of concordance calculated for the four rounds of competition over each experimental condition for numbers of wins per round.

	Rats (water)		Rats (food)		Fowls	
	Floor	Rearing	Floor	Rearing	Floor	Rearing
Weights	0.61^{++}	0.52^{+}	0.44	0.71^{++}	0.55^{+}	0.77^{++}
Times	0.35	0.62^{++}	0.29	0.51^{+}	0.86^{++}	0.87^{++}

+ : $p < 0.05$

++ : $p < 0.01$

TABLE 6.3

The values of rank correlations calculated between times and weight gains for both rearing and floor responses for the number-of-wins measure.

	WEIGHTS	TIMES	BETWEEN	
	R/F	R/F	Rearing	Floor
Rats (water)	1.00^{++}	-	0.89^{++}	-
Rats (food)	-	-	-0.24	-
Fowls	0.79^{+}	0.89^{++}	0.71^{+}	0.54

+ : $p < 0.05$

++ : $p < 0.01$

TABLE 6.4

The values of Spearman rank correlations calculated between the twelve days baseline weight gains and the first round of competition on both responses.

	RESPONSE	
	Floor	High
Rats (water)	0.96^{++}	0.57
Rats (food)	0.86^{+}	0.57
Fowls	0.46	0.84^{+}

+ : $p < 0.05$

++ : $p < 0.01$

TABLE 6.5

Spearman rank correlations between the rank orders of the amounts consumed and the total time orders for the first rounds of competition.

	Floor	High
Rats (water)	0.86^{+}	0.61
Rats (floor)	0.39	-0.04
Fowls	0.43	0.00

+ : $p < 0.05$

CHAPTER SEVEN

THE APPROACH RESPONSE AND PERFORMANCE IN THE DOMINANCE TUBE

C H A P T E R S E V E N

Introduction

The dominance tube was introduced as a measure of social dominance in rats by Schumsky and Jones (1966) and has since proved to be a popular technique. This apparatus requires animals, trained to run for rewards to opposite ends of a narrow runway, to confront each other at the centre. The animal retreating to the end from which it started is regarded as being the subordinate. Few attempts to validate this apparatus as a social measure have been made, and as a result it has been open to criticism. For example, Hoyenga and Rowe (1969) claim that performance in it is merely a reflection of individual differences in the approach response in rats, while Lindzey, Manosevitz and Winston (1966), using the dominance tube for mice, criticise it because the physical restrictions imposed could easily inhibit the expression of the range of behaviours required to denote dominance. This second criticism is equally applicable to rats.

Wilson (1968) has noted a relationship between running speed and competitive position in the dominance tube and in an experiment designed specifically to investigate this relationship, Brennan (1969) found that "overall speed was highly correlated with dominance." Brennan also observed that the "number of times the dominant subjects progressed without interference from the submissive subjects was not highly correlated with dominance" and thus concluded that the dominance tube could be used as a valid social measure. However there are four reasons why this supposed validation cannot be regarded as definitive: (1) time must be allowed

for slowing by the rat when it is faced by any object (animate or inanimate), (2) rats are likely to be slower in retreat than in advance regardless of the test conditions, (3) the subordinate, despite its social position, has also been rewarded for approaching the far end of the runway, and (4) in most studies contestants start from a stationary position in the middle of the runway, which does not appear to be the case in the Brennan study. In contrast to Brennan's work, Schumsky and Jones (1966) reported a low correlation between the last day's habituation running speeds and competitive performance, although they did note a high correlation between body weight and competitive performance.

The differing results for the time validations of Schumsky and Jones, and Brennan, can probably be attributed to the differing phases of the experiment from which the times were taken. Wilson (1968) and Brennan both obtained their times during competition, whereas Schumsky and Jones correlated times before competition with subsequent competitive performance. Therefore what must be established is which of these correlations is the more appropriate for methodological validation of the dominance tube. Logically, in view of the fact that during competition in the apparatus animals are always stopped in the middle and confronted with an opponent, it would seem likely that the subordinate animal will exhibit a lesser approach response than a dominant animal under such conditions, especially after a number of competitive trials had been completed. It appears that a low correlation between the approach response and competitive performance under these circumstances would provide some support for the validation of the dominance tube. However a high correlation would not

necessarily invalidate it. Thus the Schumsky and Jones' method seems preferable since a low correlation would demonstrate a possible social effect on the approach response whereas a high correlation would demonstrate that this apparatus is merely a reflection of the approach response. This theoretical argument is supported by the experimental evidence of Tsai and Napier (1968) and Work, Grossen and Rogers (1969) who have demonstrated the rapid development of "social inertia" or habit strength within this apparatus, producing habitual defeat among the losers within a relatively short period. The magnitude of this habit strength is vividly illustrated by the latter study which found that these effects were sufficient after twenty-one days of competition to over-ride the effects of injections of testosterone propionate.

One may also question Schumsky and Jones' validation in that their correlation was dependent on the rank order of only one day's times before competition. Even though these authors state that the median time for each animal was reliable, to within one second, for the final three days of habituation in the first of their two experiments, this claim is not made for the second experiment. Their correlation was made between one day's running speed and the "mean dominance score" which was calculated from nine days of competition, with known reliability. The extent of the reliability of the time measures over an equivalent number of observations to those used for the competitive correlations was not indicated for either experiment. It can be seen that, while there is some data pertaining to the relationship between running speed and competitive behaviour in the dominance tube, the issue is far from resolved. It is also apparent that other measures of the

approach response, such as approach force (Brown, 1942), have been ignored.

Apart from this lack of validation there is a significant procedural difference between the original study of Schumsky and Jones (1966) and those of such authors as Wilson (1968), Brennan (1969) and Hsaio and Schreiber (1969). This relates to the large differences in pre-competition habituation in these studies. Although Schumsky and Jones habituated their animals for 27 days, other authors have used considerably less time: 5 days (Hsaio and Schreiber, 1968), 6 days (Brennan, 1969), and 8 days (Wilson, 1968). It is possible that under these widely varying conditions, the concomitants of competitive success are somewhat different.

This study attempts to describe the relationship between the approach response and competitive performance in the dominance tube under both long and short periods of habituation.

Subjects

The Ss were 14 male hooded rats (N.Z.B.W.S.) approximately 180 days old at the beginning of the experiment and housed in groups of 7 in cages measuring 0.75 x 0.33 x 0.45 m high for two weeks before testing began. They were maintained on a reversed light-dark schedule and ad lib. food was available. The weight of the Ss initially ranged from 260 to 305 g.

Apparatus

This consisted of a straight runway 1.21 m long, 6.3 cm wide and 6.3 cm high with a guillotine door at the

centre. At both ends of the runway there were guillotine doors which led to goal boxes measuring 22.9 cm long, 8.9 cm wide and 8.9 cm high. The body of the apparatus was constructed of wood painted with a white semi-gloss but the roof was constructed of perspex to enable observation.

At one end of the apparatus a hole was drilled through the outside wall of the goal box. Through this hole the S could be harnessed to a force-measuring device outside, by means of a light-weight cord. This cord was attached to the rats via a leather harness which fitted comfortably around the front legs and thorax. The force-measuring apparatus consisted of a 1.21 m weighted rod suspended towards the centre on a metal axle. When the rat moved towards the reward end of the dominance tube the cord, which was attached to the top of the rod, pulled this rod in an arc towards the dominance tube. The degree to which the rod moved was indicated on a calibrated scale mounted beside the rod. In order that the rat would not be pulled backwards by the weight a small cog was attached to the axle and a brake mechanism applied to this, so that the scale was divided into 14 discrete units. A release mechanism was also provided, so that after 5 sec pulling, the cord was disengaged from the force apparatus and the animal permitted to run for its reward. The cord was of sufficient length that it became taut at the central dividing door.

A varying range of forces could be measured with this apparatus by adjusting the weights on the rod and by altering the distance from the dominance tube to the rod. The range chosen to be represented by the 14 units was 20 - 280 g, although this was decreased on the final two days of measurement to 15 - 120 g. These ranges enabled relatively

sensitive measures throughout the normal range of forces observed and also provided some indication of any exceptionally high forces, which occasionally occurred on the less sensitive units towards the horizontal plane. A schematic diagram of this apparatus may be seen in Fig. 7.1.

Procedure

Both groups of rats were placed on a 23.5 h water deprivation schedule. The "long" habituation group was introduced to the dominance tube for 2 days for 10 min per day with all the guillotine doors open and a water bottle attached to both ends of the apparatus. On Day 3 they were run individually from each goal box to the other with the central guillotine door opened for 4 trials to each end. All of these trials were rewarded with 10 sec drinking from a tube attached to the goal box. This procedure was followed for a further 25 days until the mean time taken to traverse the apparatus was less than 6.6 sec. On the 28th and 29th days the Ss were run with the middle door closed. For these trials Ss were required to wait for 10 sec in the middle of the runway; the guillotine door was then opened and they were allowed to proceed to the goal box. Throughout this period all Ss were run with the harness on. A final 6 days of habituation followed with the cord attached to harness and force-measuring apparatus. The cord became taut at the middle of the runway and, after 10 sec, the guillotine door was raised and the force with which the rat moved towards the reward was measured for 5 sec; after which time the release mechanism freed the animal and allowed it to run to obtain the reward. On the remaining 4 trials the animals were run

in the opposite direction with the central door open, and times were recorded.

Competitive testing then began. Three paired comparison rounds of competition were conducted. Unlike many previous dominance tube studies, in which a paired comparison round of competition has been completed in a single day with each S competing against all the others once or twice, the present study allowed 7 days for the completion of one paired comparison with each animal competing against only one rat daily but over 8 consecutive trials. In order to avoid extinction of the running response in the defeated animal, this rat was removed from the start box, placed in the runway, and allowed to run freely to the opposite end. This procedure not only enabled one round of competition to be compared with an equivalent number of days of baseline measures for the individual, but also made the procedure of the present attempt to validate the dominance tube the same as that in the previous analysis of the limited access measure of dominance in rats (Chapter 6).

For the "short" habituation group the habituation procedure was similar to that employed by Brennan (1969). In all there were 7 days of habituation. On Day 1 the animals were placed in the apparatus for 10 min with the water bottles attached to both goal boxes and with all doors raised. During the remaining 6 days the animals were run from alternate goal boxes for 5 trials per day, with the middle doors raised and times were recorded. The starting end for the first trial was alternated from day to day to retain equality of reinforcement for both goal boxes. On the 8th day the middle door was closed and the animals were detained for 10 sec at

the centre of the runway before being allowed to proceed towards their reward, which was again given in the form of 10 sec drinking. Competitive trials then began and three rounds of competition were conducted in the same way as for the "long" habituation group. Because of the short habituation time and the high individual running times it was not feasible to attach these animals to the force-measuring apparatus and consequently times measures gave the only indication of the response recorded.

Results

Long habituation A Kendall coefficient of concordance was calculated for the rank ordering of the median times taken to traverse the apparatus for each rat over the final 6 days of habituation. This value proved to be significant ($w = 0.69$, $p < 0.01$). The same statistic was calculated for the means of the force measure, again revealing a significant value ($w = 0.52$, $p < 0.01$). A third measure of the approach response was calculated from the value for the mean force exerted by each animal for the day divided by its body weight on the same day; this providing a "force per body weight" measure. A Kendall coefficient of concordance for this measure revealed a value of 0.34 ($p < 0.05$). Statistically significant individual differences were, therefore, demonstrated for all three measures of the approach response.

The position of each animal in the dominance order for each round of competition was calculated from the total number of wins for each animal over the 6 competitions. The weight order which was used for the correlations was derived from the average weight for each animal from the last 6 days

of habituation and the 3 rounds of competition, during which time the weights of each rat were recorded daily. Spearman rank correlations were calculated between all of these orders and the values may be seen in Table 7.1.

It is apparent that the body weight of the animals was closely related to the total force with which they pulled, and thus to the "force per body weight" measure. The only other significantly high correlation is that of the reliability between Rounds 2 and 3 of competition. No significant relationship was observed between any of the approach responses and subsequent competitive performance.

The force with which the animals pulled towards the goal box decreased from Day 1 (mean weight = 117.9 g) to Day 6 (mean weight = 59.06 g). A Wilcoxon matched-pairs signed-ranks test ($d = 0$, $p < 0.01$) demonstrated that this difference was a significant one.

Short habituation A Kendall coefficient of concordance was calculated for the median times during habituation and was found to be significant ($w = 0.63$, $p < 0.01$). The mean median time for the last day's habituation was 40 sec for the short habituation group, which was far greater than the mean median time shown by the long habituation group (3 sec). A weight order was calculated from the average weight of each animal during the 6 day's habituation and the 3 rounds of competition, and this was used for the correlations shown in Table 7.2. Position in the dominance order was derived in a similar manner to that for the long habituation group. Spearman rank correlations were calculated for the times and weights, and the 3 rounds of competition, the results also appearing in Table 7.2.

The average time taken to traverse the runway proved to have a significant inverse relationship with the second and third rounds of competition, while body weights proved to be positively correlated with these orders. The competitive orders on Rounds 2 and 3 of competition proved to be highly correlated.

Discussion

For the long habituation group body weights, total force exerted, and force/body weight measures were highly correlated, although they did not correlate significantly with the time order. None of the measures for the approach response correlated highly with competitive performance. Under the long habituation condition, therefore, the results of this study suggest that the criticism of the dominance tube, as being a reflection of the approach response, are unfounded. However it is worthy of note that Schumsky and Jones (1966), who used an habituation period very similar to that used here, did find a relationship between body weight and competitive performance. If, as in the present study, the body weights were highly correlated with the force measure, one may suggest that their orders were, in fact, based on the force dimension of the approach response. The differences between the present results and those of Schumsky and Jones may result from the differing competitive procedures used, or from differences in the sizes of the competitive groups employed. Regardless of the reason it is clear that the dominance tube must be examined closely with respect to these sorts of methodological differences.

The results for the short habituation group require further interpretation. Here body weight proved to have a relatively high correlation with competitive performance in

the second and third rounds of competition and the time order was found to be negatively related to the two competitive rounds. The first correlation corresponds with the results of Schumsky and Jones (1966) and tends to invalidate the dominance tube as a measure of dominance, although under the short habituation period the relationship between body weight and force exerted can no longer be assumed. However the inverse relationship with time is harder to interpret. Although it could be regarded as a validation of the dominance tube as far as the time measure of the approach response is concerned, there are two possible interpretations of the relationship. The first and social hypothesis is that the rats which were formerly the slower to negotiate the apparatus were more susceptible to the social facilitatory effects of competition. Such a relationship between response skill and social facilitation has been observed by Church (1962) when using a bar pressing response with rats. But in view of the results of Winslow (1940), Carnathan and Church (1964) and Kanak and Davenport (1967), who investigated social facilitatory effects on running speed in a competition runway situation and found little or no evidence for competitive facilitation it seems unlikely that this has occurred in the present study. Procedural differences between these and the present study preclude direct comparison however; a social facilitation effect should be experimentally investigated using the dominance tube.

The second possible interpretation for the negative relationship between running times and competitive performance is that the slower animals on the approach measure are also slower in retreat. This would imply that these animals are

merely generally less active and have greater inertia in the apparatus and, as a result, they take longer to move anywhere from the centre point in the runway. Consequently the more active animals retreat first, since this is the only quick, unobstructed movement available. Observation of the rats during competition would seem to support this hypothesis in that the ultimate loser was frequently observed to make several rushes at the opposing animal, which itself remained stationary for some time and then only slowly moved down the tube even if the opposing rat retreated as far back as the opposing goal box. This second hypothesis should also be evaluated experimentally. However it does illustrate one deficiency in present attempts to validate the dominance tube in terms of the approach response only, when there are two definite behavioural components in the dominance tube: approach and retreat.

Whichever of the two hypotheses presented is correct, social facilitation or retreat, it is clear that the length of habituation before testing in the dominance tube is an important determinant of the validity of any study using this apparatus, and that this period must be maintained at the level suggested by Schumsky and Jones (1966) if the order obtained is to be guaranteed to be unrelated to the non-social attributes of the subjects. Even if these conditions are met, further validatory work is required before one can regard the dominance tube as an unequivocal index of social dominance in rats.

FIGURE 7.1

A diagrammatic representation of the force-measuring apparatus.

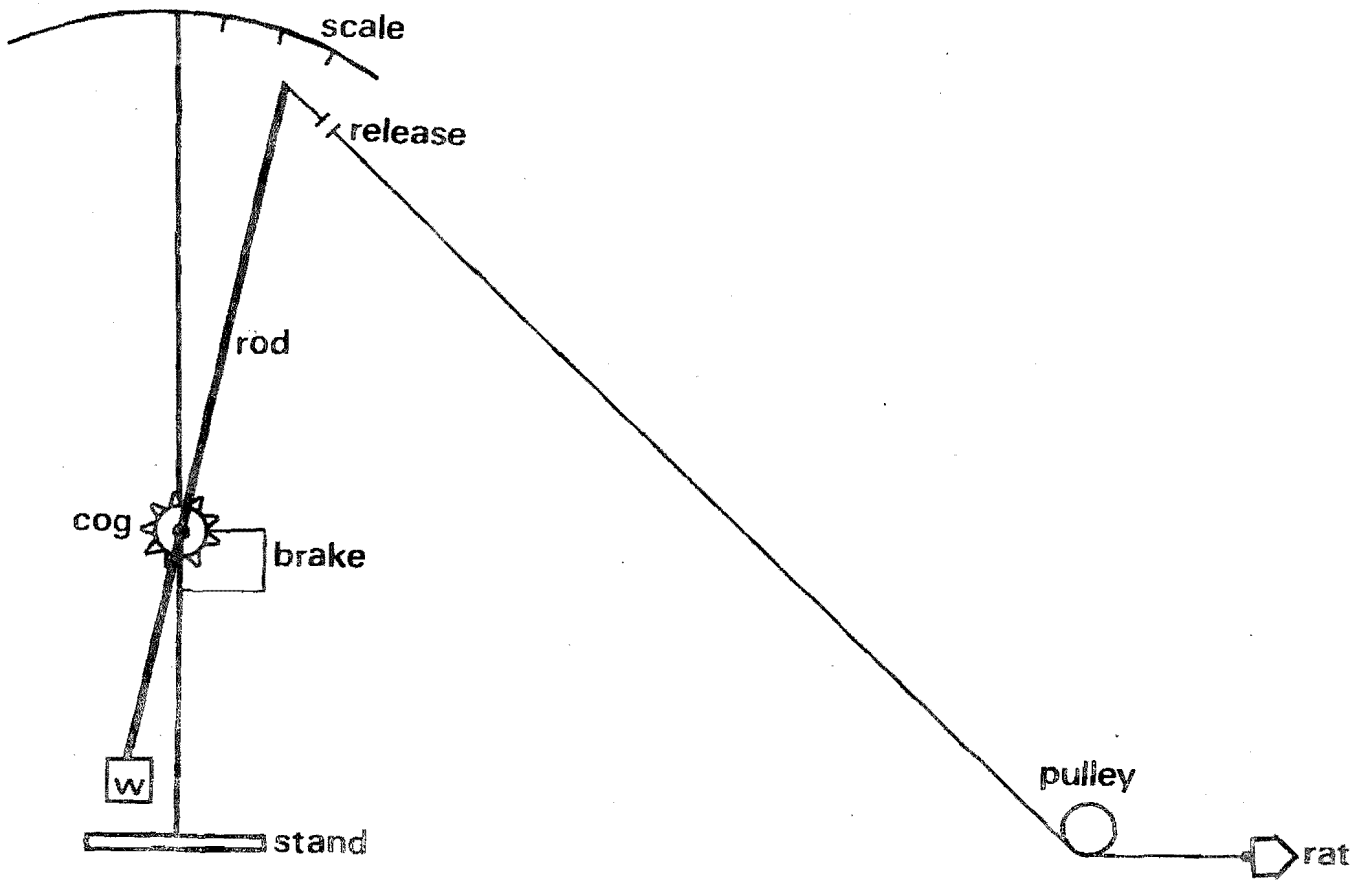


TABLE 7.1

Long-habituation group Spearman rank correlations calculated between the various measures of approach response, body weights and the orders in the three rounds of competition.

	Time	Force	Body Weights	Force/g	Competition 1	Competition 2	Competition 3
Time	X	0.40	0.42	0.24	0.56	-0.43	-0.31
Force		X	0.86^{+}	0.96^{++}	0.11	-0.03	-0.14
Body Weights			X	0.75^{+}	0.46	0.32	0.21
Force/g				X	-0.11	-0.11	-0.25
Competition 1					X	0.21	0.14
Competition 2						X	0.86^{+}
Competition 3							X

+ : $p < 0.05$ (two-tailed)

++ : $p < 0.01$ (two-tailed)

TABLE 7.2

Short-habituation group Spearman rank correlations calculated between the time measure of approach response, body weights and the orders in the three rounds of competition.

	Times	Weights	Competition 1	2	3
Times	X	-0.61	-0.39	-0.79^{+}	-0.79^{+}
Weights		X	0.43	0.74	0.71
Competition 1			X	0.64	0.73
Competition 2				X	1.00^{++}
Competition 3					X

+ : $p < 0.05$ (two-tailed)

++ : $p < 0.01$ (two-tailed)

CHAPTER EIGHT

INTERLUDE

C H A P T E R E I G H T

Although it was suggested in Chapter 1 of this thesis that it would be desirable that the effects of the competitive order on social discrimination in a competitive situation should be established as an aid to assessing the internal validity of any competitive order, no such effects were observed in the ferret studies of Chapter 2. It was postulated that this was because the competitive order in ferrets was more a reflection of individual differences in competitive skill at the particular competitive task than social dominance.

However it can be argued that the results of the ferret study were an outcome of methodological rather than social deficiencies. Because of this it was decided to attempt to measure competitive social discrimination in the domestic fowl under comparable conditions to those used in the ferret experiments. If the fowl proves to be unreceptive in this situation this type of experiment may have to be reviewed more closely in order to assess its limitations as a social index.

CHAPTER NINE

COMPETITIVE SOCIAL DISCRIMINATION IN A SMALL FLOCK OF DOMESTIC FOWL

CHAPTER NINE

Introduction

Dominance orders in the domestic fowl have been described in great detail in a number of studies (for review, see Wood-Gush, 1971) but relatively little information is available as to the effects of social dominance on other behaviours such as social discrimination and preference. In two early investigations Murchison (1935a, 1935b) found that dominance relationships were related to approach distance among cockerels in a runway and that, in a social preference study, males tended to approach caged submissive cockerels more than dominants while females preferred dominants. However using adult fowls and the same preference apparatus, Guhl (1942) failed to demonstrate any meaningful dominance discriminations for either sex. In this study, males discriminated for females in a male-female choice while females did not make a sex discrimination. These contradictory findings may be a result of either (1) the differing ages of the subjects used by Guhl and Murchison, (2) the instability of the orders in Murchison's group of males, or (3) the different viewpoints in their data analysis. Both experiments also show methodological limitations. In the absence of incentives for the social discrimination each animal was presented with each choice twice only, thus preventing any meaningful analysis of any one discrimination (the probability of all possible outcomes equalling 0.25); Guhl reported that there appeared to be individual differences in behaviour between his subjects but these could not be examined statistically. The lack of physical contact between the fowls

in this apparatus suggests a further constraint, in that Maier (1964) has shown this contact to be an essential factor in the development of social recognition in hens.

In the only other experiment of a comparable nature King (1965a) found a similar relationship to that reported by Murchison (1935a); nearest approach distances for cockerels were greater for dominant animals than submissives. This did not occur for hens, but since the age of the animals was not stated the discrepancy may be interpreted in terms of either sex or age variables. Using three hours food deprivation and providing food with the stimulus animal at the end of the runway the experiment was repeated, with the result that all approach distances now became zero. This second result is interesting in view of the subsequent findings of King (1965b) who observed many transient reversals of status in cockerels as access to food was restricted to a point source. It may well be, therefore, that under food motivation or competition the discrimination of dominance disappears or becomes irrelevant.

In summary, while evidence exists for social discrimination against social dominance in males but not in females, there are some doubts as to whether social discriminations can be made under the incentive of having to compete for food. The present study was designed to test for social discrimination in pullets under competitive conditions. The use of food deprivation as motivation allowed a comparatively large number of trials to be conducted for each discrimination and the competition ensured direct contact between subjects thus overcoming the two major disadvantages of the method used for social discrimination in previous

choice studies. Discriminations observed under these conditions were intended not only to demonstrate dominance discriminations in females but also to illustrate the relevance of the social order under competitive stress. It was also decided to include one male in the group in order to provide a re-examination of the results obtained on male-female discriminations by females, by Guhl (1942).

Subjects

The birds used were 4 females and 1 male of a broiler strain originating from a three-way cross White Leghorn x Australorp x Rhode Island Red. The Ss were 90 days old at the beginning of the study and had been housed together in a pen measuring 3.0 x 1.6 m for 40 days prior to experimentation. Ad lib. water and grit were available and each animal was marked with alcohol dye to permit easy identification.

Apparatus

The apparatus used was a modified version of the "wedge" technique developed by Candland, Mathews and Taylor (1968), the form of which is represented in Fig. 9.1. As well as the detention chambers and competitive wedge of the original apparatus a start box was added which led to the detention chambers via guillotine doors. Once the animal had entered a detention chamber a second guillotine door was raised providing access to the wedge. This enabled a subject, trained to run through the apparatus, to choose its competitor and enter either of the detention chambers when both doors leading to them were simultaneously raised. The sides of the apparatus were made from a slotted angle iron frame covered with 1.5 cm

diameter chicken-wire so that ongoing behaviour could be observed. The wedge partition was also constructed from this wire as were the guillotine doors between the start box and detention chamber. This meant that during experimentation all Ss were clearly visible to each other. The lids were made from 0.3 cm thick hardboard which was also used to make the guillotine doors between the detention chambers and the wedge. A small piece of meat (about 2.5 g) was provided as a competitive reward and it was fed manually on a flattened metal rod through a gap 15 cm above floor level towards the thin end of the wedge.

Procedure

The animals were placed on a 24-h food deprivation schedule and each bird was trained to run through the apparatus for the meat reward for 10 trials per day for 20 days, by which time the average running time from start box to wedge was 4 sec or less. In order to control for any developing side preferences the detention chamber through which the animal was directed was varied according to the Gellermann series of stimulus sequences (Gellermann, 1933) by opening the door of only one detention chamber. The training period was followed by four rounds of paired comparison competition with each pair competing for 10 rewards per round. Each animal competed only once each day so that two pairs of animals were required for competition and the fifth was run as for the training trials. Using this procedure each round of competition took 5 days to complete.

Competitive trials began with the placing of the 2 Ss in the detention chamber. They were then released

simultaneously into the wedge and a 5 sec period elapsed before the reward was presented. The animal obtaining the reward was regarded as the winner or dominant animal for the trial. It was removed from the wedge, placed in the start box and given entry to one of the detention chambers which were again presented according to the Gellermann series. The loser, meanwhile, was fed in order to provide the same reward from the apparatus and then returned to the other detention chamber in the same manner as the winner.

The 20 days of competition were succeeded by 30 days of social discrimination in which each animal had a choice for competition between all possible pairs of the remaining Ss on 10 competitive trials. These trials were conducted as follows. The stimulus animals entered both detention chambers and the S was placed in the start box. After 30 sec both doors leading to the detention chambers were opened simultaneously. When the animal had made its choice both these doors were then closed. The competition proceeded as before with the third animal later being released and rewarded. Presentation of the positions of the stimulus animals were varied according to the Gellermann series. The order of presentation of the pairs for each animal was randomised and each animal was given a choice every fifth day. The two spare animals were run for 10 trials each day as in the training sessions. Social discriminations were followed by a fifth round of paired comparison competition.

Throughout the study a record was also kept of all aggressive encounters within the apparatus. During this time the Ss were provided with a small dietary supplement of wheat or commercial laying mash immediately after testing.

Results

The results of the paired comparison competition were analysed in two ways. In the first analysis position in the dominance order was computed in terms of the total numbers of trials won in a completed round regardless of the number won against any particular opponent. For the second analysis each of the ten competitive pairs were examined separately with the animal gaining the reward on more than five of the ten possible occasions being regarded as the more dominant. These results were then tested for linearity in the manner suggested by Landau (1951). Both measures yielded identical and consistent orders over the final three rounds of competition. As shown in Table 9.1, the second measure was not only reliable but also represented a perfect linear hierarchy ($h = 1$).

Observed aggressive responses within the apparatus showed that, although the rate of aggression was not high, with only 130 pecks being delivered throughout the entire study, they did prove to be intransitive among the females and formed a linear hierarchy. This is shown in Table 9.2. No consistent relationships occurred for the male which was observed to peck a female (f1) once, but in turn was pecked by her twice.

Each social choice was analysed using a length of longest run test with known probabilities (Bradley, 1968). Using this test a significant discrimination was defined as a continuous run of six choices for one stimulus animal. The probability of this event occuring by chance is less than 5%. The results for each subject in relation to both competitive and aggressive orders may be seen in Tables 9.3 to 9.7 and a summary appears in Table 9.8. Discriminations

made by the male are not represented in relation to the aggressive order since only one significant choice was observed and this was against aggressive dominance. Table 9.9 shows the proportion of wins per number of competitions obtained in the stable paired comparison rounds of competition (Rounds 3, 4 and 5) as compared with the same proportions obtained when competitive choice was available and the animal acted as the subject and the stimulus.

An inspection of those occasions on which a choice was not found did not reveal any universal competitive strategy but significant side preferences were observed on five separate occasions.

Discussion

In contrast to the results of Guhl (1942) and King (1965a) the pullets did make a number of statistically meaningful social discriminations; this may be attributed to the provision of both a choice instead of an approach distance, and an analysable number of trials for each discrimination. That these discriminations were made in the face of competition indicates that even though King (1965a) found all approach distances reducing to zero in a food deprivation situation, individual discriminations can still be made if a choice is available.

Investigating the hypothesis that dominant animals are avoided presents immediate difficulties in that two distinct "dominance" orders were observed: for competitive and aggressive responses. Although the male retained a reliable position in the competitive order it was independent of the aggressive order seen in the females. In that Guhl (1958)

observed unrelated unisexual orders in heterosexual flocks of approximately the same age this is not surprising, but it was also noticeable that the competitive and aggressive orders of the females differed. In view of the work of Candland et al, (1968), who found a very high correlation between competitive and aggressive orders in males of varying ages and concluded that the competitive order was representative of the aggressive one, this is an unexpected result. The differences between the two studies may be due either to the sex differences of the subjects or to the modifications made in the present investigation to the wedge technique. Whatever the cause, further clarification of the relationship between the peck order and competitive performance is required. The position of the male in the competitive order is also very interesting, in that if the competitive order is to be regarded as synonymous with aggressive orders the work of Domm and Davis (1948) and Guhl (1950) would suggest that the male should have been the alpha animal. The first study found that peck order reflected the amount of male hormone in intersexual birds and castrated males while Guhl reports that females were generally submissive to capons.

Finding a dichotomy between competition and aggression the present study examined the possibility that social choices would be made against dominance in relation to both orders. Since the paired comparison competitive order remained constant from Rounds 4 to 5 we may assume that the observed social discriminations may be related to a stable hierarchy, and becasue there were no aggressive reversals this assumption may also be made in regard to the peck order. For the competition order there was some support for the hypothesis.

In those choices in which one stimulus animal was more dominant and the other more submissive five choices were made for the subordinate and none for the dominant with five non-discriminations whilst in those choices in which both stimulus animals were more or less dominant than the chooser four choices were made for the subordinate and two for the dominant with four non-discriminations. It is worthy of note, however, that both of the choices for the dominant were made to the male. A similar picture is seen in relation to the female aggressive order. Here, where there was a choice between a more or less dominant animal, the only choice was for a subordinate, and when both subjects were above or below the chooser there were three choices for the submissive but also one for a dominant. Thus when an animal had a choice between a subject more or less dominant than itself the hypothesis that the animal would choose the submissive is supported in relation to both orders, but when both animals are either above or below the chooser in the social order this relationship is not as clear although some support is obtained. It is particularly important that this second problem be further investigated because the existence of dominance related preferences could provide quantitative evidence relevant to a social distance approach to dominance which would be applicable to the development of sociological power models of the type described by Kemeny, Snell and Thompson (1957).

In contrast to Guhl (1942) Table 9.8 demonstrates that the male was generally preferred when a discrimination was made between it and a female. This may be explained by the consistent lack of aggression shown by the male, although Guhl (1958) reports that in his heterosexual flocks, containing

a number of males, females were definitely under social stress and had difficulty in feeding. Although methodological differences between the present study and Guhl's pen observations are obvious and his effects are probably due to the high proportion of males in his flocks, it appears that valuable information may be gained from a closer examination of sex differences in competitive behaviour.

Despite the interesting directions of the choices that did occur, one of the most significant features of the results is the large number of non-discriminations; these account for almost two-thirds of the data. The finding that dominance was not always aversive tends to support the proposition of King (1965a) that the degree of pecking which is consistently maintained in stable flocks is attributable to the readiness of fowls to approach more dominant animals under the incentive of food or the necessity of competition. A simpler explanation may be that the number of trials for each choice was not great enough for consistent discriminations, but this may be discounted since all fowls chose at least once and the number of preferences did not increase towards the end of the study. It is also of interest that the three more submissive animals in the competitive order improved their proportion of competitive success quite markedly when allowed to choose their competitors, thus suggesting that they were able to make some positive adjustment in the face of the social frustration imposed by competition. Although the number of subjects used in the present study is too small to allow definitive statements the results do indicate that more quantitative information on the importance of such social adjustments can be obtained by the method used here.

This experiment was conceived as a simple demonstration of social discrimination in pullets; however the various side-issues raised by the use of the competitive method developed to be of equal importance to the original problem. As Wood-Gush (1971) points out, "-the daily life of the average fowl is very likely to bring it thwarting, for competition around the food trough may be intense even in settled peck orders for birds of fairly high status." The type of experiment described in the present study should prove to be useful in the practical and theoretical analysis of such behaviours which have, as yet, been largely ignored.

FIGURE 9.1

A diagrammatic representation of the competitive choice apparatus. S - start box, G - guillotine door, D - detention chamber, W - wedge, R - reward. Scale dimensions: length of detention chamber = 0.73 m, height of apparatus = 1 m.

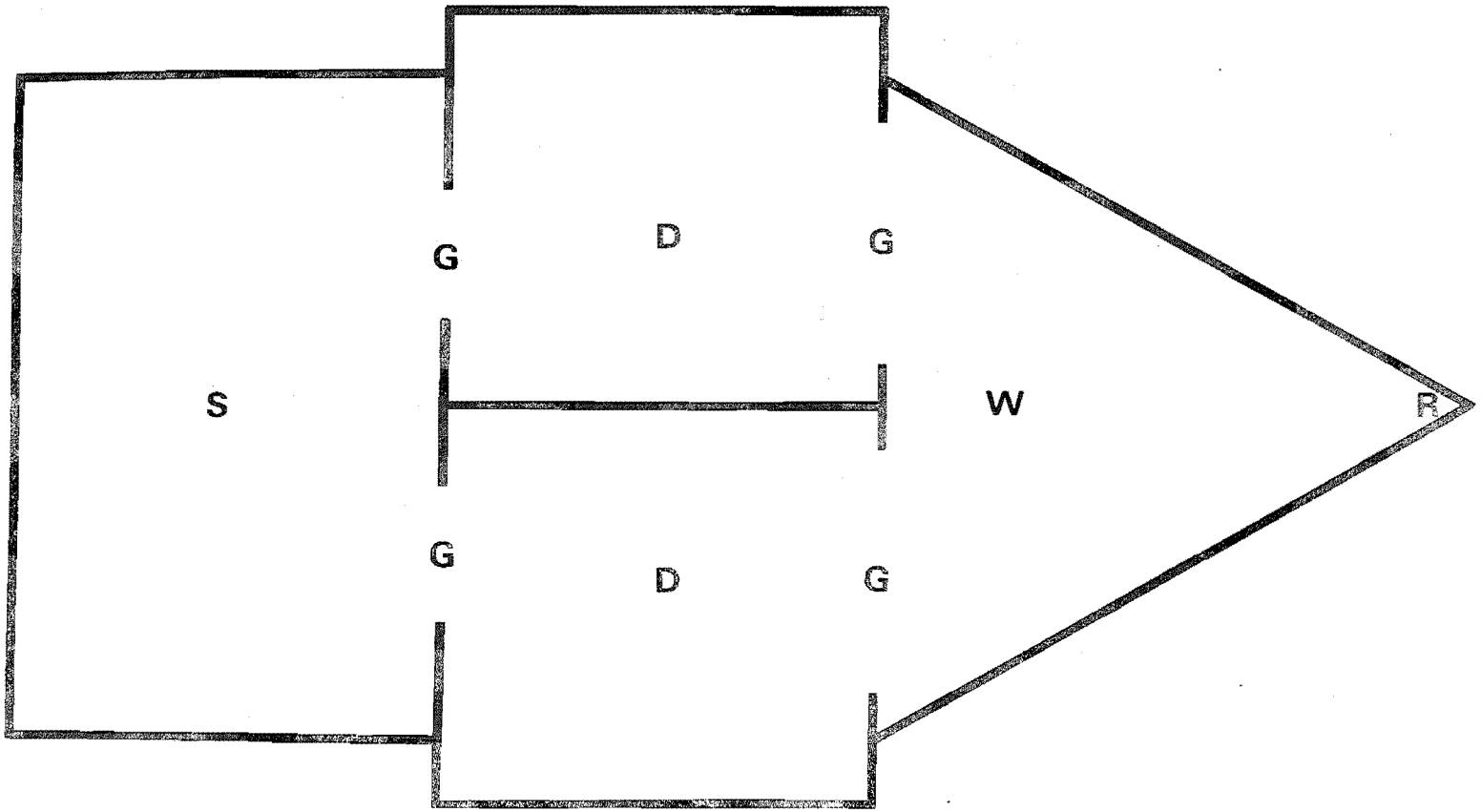


TABLE 9.1

Competitive hierarchy found in the Third, Fourth and Fifth Rounds of competition.

Subjects	F_1	F_2	M	F_3	F_4
F_1	X	+	+	+	+
F_2		X	+	+	+
M			X	+	+
F_3				X	+
F_4					X

A + sign indicates that the animal represented in the row won the reward on more than five of the ten trials against the animal represented in the column.

TABLE 9.2

The peck order of the females.

Subjects	F_1	F_2	F_3	F_4
F_1	X	14	13	26
F_2		X	18	25
F_3			X	34
F_4				X

The numbers show the number of times the animal represented in the row pecked the animal represented in the column.

TABLE 9.3

Choices made by subject F_1.

	$f_2(f_2)$	m( )	$f_3(f_3)$	$f_4(f_4)$
f_2	X	n	n	n
m		X	+	n
f_3			X	n
f_4				X

A + sign indicates that the animal exhibited a preference for the animal in the row over the animal in the column. The n sign shows that there was no significant choice for either animal. Subjects represented by a small letter were subordinate to the chooser while animals represented in capitals were dominant. Letters in brackets indicate the relative position in terms of the aggressive rather than competitive order.

TABLE 9.4

Choices made by subject F_2.

	$F_1(F_1)$	m( )	$f_3(F_3)$	$f_4(F_4)$
F_1	X		n	
m	+	X	+	n
F_3	+		X	
F_4		+		X

Symbols as in Table 9.3.

TABLE 9.5

Choices made by the male subject M.

	F_1( )	F_2( )	f_3( )	f_4( )
F_1	X	n	n	
F_2		X	n	n
F_3			X	n
F_4	+			X

Symbols as in Table 9.3.

TABLE 9.6

Choices made by subject F_3.

	$F_1(F_1)$	$F_2(f_2)$	M( )	$f_4(f_4)$
F_1	X			
F_2	+	X	n	n
M	+		X	
f_4	+		+	X

Symbols as in Table 9.3.

TABLE 9.7

Choices made by subject F_4.

	$F_1(F_1)$	$F_2(f_2)$	M( )	$F_3(F_3)$
F_1	X	n		n
F_2		X	n	n
M	+		X	n
F_3				X

Symbols as in Table 9.3.

TABLE 9.8

A summary of choices made in relation to both dominance orders as well as for and against the male.

	COMPETITION						AGGRESSION						MALE		
CHOICE	D/S			DD or SS			D/S			DD or SS					
Subjects	D	S	N	D	S	N	D	S	N	D	S	N	F	A	N
F_1	-	-	-	1	-	5	-	-	-	-	-	3	1	-	2
F_2	-	2	1	1	1	1	-	-	-	1	2	-	2	-	1
M	-	1	3	-	-	2	x	x	x	x	x	x	x	x	x
F_3	-	2	1	-	2	1	-	1	1	-	1	-	1	1	1
F_4	-	-	-	-	1	5	-	-	2	-	-	1	1	-	2
Totals	0	5	5	2	4	4	0	1	3	1	3	4	5	1	6

Symbols: D/S - one stimulus animal was more dominant and one less dominant than chooser, DD or SS - both stimulus animals were more or less dominant than chooser, D - number of choices for dominant, S - number of choices for subordinate, N - no significant choice, F - number of choices for male, A - number of choices against male, x - male irrelevant in this situation.

TABLE 9.9

Proportions of wins per competition for each subject.

Subjects	PC	C	S
F_1	0.92	0.70	0.73
F_2	0.57	0.47	0.65
M	0.53	0.68	0.58
F_3	0.34	0.42	0.13
F_4	0.08	0.35	0.22

Symbols: PC - paired comparison rounds 3, 4 and 5; C - when acting as chooser, S - when acting as a stimulus.

CHAPTER TEN

CONCLUSION

CHAPTER TEN

CONCLUSION

In general the results of all experiments support the suggestion advanced in the Introduction: that the indiscriminate use of competitive orders as measures of social dominance is no longer justified.

The ferret experiments demonstrate that, even though a highly reliable hierarchy of competitive performance at a particular task may be established, it is not necessarily generalisable to other closely related social behaviours and, as such, it may be regarded as a methodological artifact rather than a manifestation of dominance. Investigations of the limited access measure in the rat revealed that orders on this measure reflect individual skills at the competitive task and have little generality to other tasks. As a result this measure cannot be regarded as a measure of social dominance for this species, at least with a paired comparison procedure. These findings, when taken in concert with the lack of relationship between dominance tube and limited access measures shown by Lindzey, Manosevitz and Winston (1966) for mice and the dependence on response skills for performance in two competitive tests in gerbils (Wechkin and Reid, 1970) would tend to invalidate the use of competitive tests as indicators of dominance in rodents generally. Even in the case of the chickens there was a failure to demonstrate unequivocal support from their competitive behaviour in the limited access or social choice situations for the concept of social dominance. It is very clear that more work is needed

on the competitive behaviour of this, the classical dominance animal.

The methodological difficulties encountered in Chapter 6, for both rats and chickens on the limited access measure, are also important. It can be seen that for the chickens it is doubtful whether the limited access situation can be regarded as a valid competitive measure since the birds consumed a similar amount in competition as in their baseline conditions, and this problem could not be overcome, as it was in the rat situation, by providing a water reward. Bracco and Miller (1972) also report methodological difficulties with these animals in their pain-elicited aggression studies, so that a shock avoidance competitive situation with this species may also have some limitations. Both rats and chickens in the limited access situation failed to show a clearly defined relationship between times spent in control of the reward source and amounts consumed as measures of competitive performance, and it is obvious that if limited access measures are to be continued a decision must be made as to which can be regarded as the appropriate measure.

Apart from the specific details of the methodological problems, however, it can be seen from all the experiments reported in this series that the methodologist in this field, far from clearing up minor points, will be establishing the basis for a fresh and more realistic approach to competitive analysis and general theories of social structure in laboratory conditions. Behaviour in such situations as the dominance tube must be analysed completely before they are accepted as measures of social dominance. It is a reflection of the current tendency to over-simplification in laboratory studies of

competitive dominance that (1) even though the dominance tube has been in use for six years, with many publications resulting (e.g. Hsaio and Schreiber, 1968; Ward and Gerall, 1968; Uyeno, 1967, 1971; Brennan, 1969; Tsai and Dexter, 1970; Masur et al, 1971; Work and Rogers, 1972) no attempt at complete analysis has been made, and (2) procedural differences between studies have been completely ignored. Perhaps the dominance tube studies may follow the pattern set by the limited access measure: that is, only after thirty years, when the quick studies relating all possible extraneous behavioural indices, early experience manipulations and drug effects to performance in the dominance tube have been completed, will the more difficult process of evaluating the social meaningfulness of this measure begin.

It is also important to note that the criticisms of the competitive measures of dominance which have arisen from these experiments have been derived from only very slight manipulations of the competitive situations. Both the ferret and chicken social choice experiments were conducted under similar or identical competitive conditions to that in which the original competitive orders were generated, and the degree of response change in the limited access study was very small. This would seem to indicate that, if future studies are prepared to use a series of systematic response changes, the results gained could well provide more criticisms of the equation of competitive orders and social dominance. What has been achieved in this thesis can only be regarded as a first very tentative step in relating competitive behaviour to other general social concepts. The importance of basing the social interpretation of competitive orders on the competitive response

required and the generality of the order to other social behaviours has, however, been clearly demonstrated. Although there is nothing new or surprising about this finding it does have a great deal of significance for any future laboratory research on competitive orders.

Firstly the adoption of a response orientation would enable laboratory studies to be brought into line with recent developments in dominance-related theory by field workers such as Gartlan (1968) and more particularly Crook (1970). Both authors have denounced the global dominance theory as being too restrictive in describing the social structure of groups. Crook also insists that the descriptions of the social organisation of the group must be made in relation to its environment. Although in his discussion he was primarily concerned with primates, such a conclusion could well be applied to all species and to the laboratory setting. Each competitive situation could be regarded as a variation of a total competitive environment which could be defined and standardised for any species and split into a series of competitive tests, each with its own specific properties but also with a degree of relationship to the other tests in the environment. If, and only if, the relationships are described between each of these tests will the analysis of the general competitive organisation of the species begin. When these tests are coupled with equally standardised situations describing such things as the relationship between space and behaviour, social preference, cooperation, and other relevant behaviours progress in conceptualisation of social phenomena in the laboratory situation may resume.

The second major advantage in the acceptance of a

response orientation for competitive studies is that such an approach would help eliminate the current tendency, as exemplified by such authors as Baeninger (1970) and van Kreveld (1970), when noting a difference in the orders between two competitive tests on different rewards for a species, to interpret this as representing two dominance orders. Unless the response requirements were exactly the same for both rewards, a response interpretation would insist that the more parsimonious explanation for any difference is that it was caused by the response change. Thus the division of the uni-dimensional concept of dominance into a series of untestable fragments would be prevented unless unequivocal experimental support was obtained for this fragmentation.

A second point raised by Crook in his review is also important in relation to laboratory studies. For too long, group processes have been regarded only in terms of representing the behaviour of a collection of individuals. Crook suggests that a more sociological (or socio-ethological) approach could well result in a resurgence of new findings and an escape from the rather sterile concepts of territory (a good criticism of which may be seen in Fisler, 1969) and dominance. Even though Crook was referring mainly to field studies it is likely that such an attitude would also prove to be beneficial in laboratory studies. Despite the fact that the "individual difference" approach has been useful in this thesis it has still been tied to the unsatisfactory concept of dominance. Techniques such as that of the sociability measure developed here could provide a starting point for group analyses in the laboratory.

In all, the results of this thesis seem to suggest that attempts to analyse social behaviour in the laboratory have been directed towards a far more difficult task than one would imagine from much of the literature about experimental measures of competitive dominance and sociability. If progress is to be made, a more fundamental methodological approach must be undertaken, together with an attempt to cast aside the global static concept of dominance.

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A P P E N D I X 1

Competitive behaviour in the New Zealand ferret (Putorius putorius furo)

Introduction

Descriptions of the social organisation of ferrets, polecats and ferret-polecat hybrids have depended up to this time almost entirely upon the observation of aggression. Poole (1966, 1967, 1972), in a series of painstaking studies, has given a detailed description of aggressive activities in both juvenile and adult animals. His observations indicate that unlike many other species the results of aggressive encounters in polecats and ferrets do not resolve themselves into simple representations of dominance-subordination relationships and that one can distinguish between at least three levels of aggressive intensity. Poole (1972) reports that the "intimidated" animal often suffers less damage during conflict than its opponent and that fighting sometimes does not reach a definite conclusion; his animals having to be separated. Poole (1967) also notes that in order to evoke aggression his subjects had to be caged apart. "In the experiments described the animals used were not cagemates the reason for this being that they normally showed aggressive behaviour only towards strangers and not towards polecats with which they were familiar."

These findings suggest either that there are no dominance relationships in stable groups or that aggression is rare because of the stability of these relationships

outside the breeding season. In order to differentiate between these alternatives it was decided to investigate the possibility of dominance relationships in New Zealand ferrets caged together, using a competitive procedure rather than the observation of aggression. Competitive procedures have proved popular in measuring dominance orders in other species when overt aggression is infrequent in stable groups (Bruce, 1941; Candland, Mathews and Taylor, 1968) and it seemed possible that the competitive behaviour might prove to be easier to interpret than the rather complex repertoire of aggressive responses available in the ferret. Competitive behaviour was, therefore, observed in both paired comparison and group situations in a modified version of the dominance tube. Later, in an attempt to relate the general activity and behavioural characteristics of each subject to its competitive performance, each animal was observed for seven days over a 15-min period and its behaviour recorded using the Bindra-Blond (1958) time-sample technique.

Subjects

The Ss were 7 New Zealand ferrets selected from a colony maintained by the Psychology Department at the University of Canterbury. The animals were caged together throughout the study in a pen measuring 1.0 x 1.0 x 2.6 m. They were aged 4.5 months at the beginning of the study and came from three litters. Details of the Ss may be seen in Table A.1.

Procedure

The study was divided into three parts. The first part was the measurement of a paired comparison competition hierarchy. Secondly, the apparatus devised for the first

part of the study was expanded so that seven animals at a time could compete for one reward. Finally, general behavioural characteristics were observed in a 2.0 x 2.0 m enclosure.

Part A. Paired Comparison Hierarchy

Apparatus

The apparatus chosen was a modified form of the dominance tube as used by Lindzey, Winston and Manosevitz (1961) for mice, and Schumsky and Jones (1966) for rats. These authors required animals trained to run for reward to opposite ends of a narrow runway to confront each other at the centre. The animal retreating to the end from which it started was regarded as being the subordinate. This method can be criticised on the basis that since only a very limited number of responses can be performed within such confined conditions free competition is not possible. Consequently it was decided to modify the dominance tube in such a way that Ss competed for access to a reward at the same location; this enabled the competitors to remain in contact for most of each trial. It also allowed the dimensions of the apparatus to be expanded so that the ferrets could freely engage in a wide variety of behaviour before the constriction of the tube was reached. The retention of the tube enabled the experimenter to channel the animals' natural enthusiasm for such a task to useful purpose. This apparatus also had the advantage that it could be easily enlarged to enable a comparison of paired and whole group competition. A representation of the apparatus may be seen in Fig. 2.1. It consisted of a start box which led, by means of a guillotine door, to a larger area - the

"decision space" - which, in turn, led to a narrow pipe (of 9 cm diameter) which was wide enough to allow one ferret to pass comfortably but not two. The body of the apparatus was constructed of wood painted with a white semi-gloss, while the lids and roof were made of perspex to permit observation of Ss.

After the competitors had occupied the start box for 10 sec they were required to run through the "decision space" to the plastic competition pipe. A compromise width was chosen for this pipe to allow for the large size difference between male and female ferrets; thus it let one male but not two females through. A hinged flap at the connection of the pipe to the "decision space" enabled the removal of ferrets hiding in the pipe. After the animals had been released from the start box and the meat taken by the winner, the reward box was tilted and the animal trapped; the second animal could then be caught by hand and duly fed.

Procedure

Each animal was trained individually to run through the apparatus for 10 trials per day for 11 days, after which the mean time per trial for each animal was a maximum of 3 sec. The reward for each trial was a small piece of meat (approximately 2,5 g) and the animal was not fed in the home cage. Milk was given as a dietary supplement each day after testing: 0,6 litres being provided for the whole group.

All animals then competed with every other animal twice for 10 trials during two randomly chosen paired comparison rounds of competition. Three pairs of ferrets competed each day, while the remaining animal was run alone, to ensure that every animal obtained 10 rewards from the apparatus per day.

After each trial the loser was rewarded as soon as it emerged from the pipe. The ferret emerging first from the pipe was regarded as being the winner or dominant animal for the particular trial. Three days of ad lib. feeding preceeded further investigations.

Part B. The Feeding Order Hierarchy

Apparatus

This consisted of an expanded version of the apparatus used to establish the paired comparison hierarchy. The dimensions of the start box were enlarged to 1.3 x 0.3 m and the "decision space" to 2.0 x 2.0 m. A wire mesh lid covered this last enclosure to permit observation of Ss.

Procedure

Each ferret was run individually for 10 trials per day for 9 days after which all animals had an average time per trial of less than 7 sec. Competitive testing began on the tenth day. All 7 ferrets were placed in the start box. After 30 sec they were released and the ferret obtaining the reward removed and the remaining 6 replaced and re-released, the winner rewarded, and so on until a complete order was acquired. Following each trial the animals were placed in a random order in the start box and a period of 4 min after the last animal was replaced would elapse before the next trial began. Two feeding orders were obtained each day. When these were completed 8 trials were carried out individually so as to maintain a degree of equality in the number of trials per reward ratio for each ferret. This also enabled a rank ordering

of individual speeds through the apparatus to be established for each day and compared with the competitive orders obtained. The feeding order procedure was continued for 10 days so that a total of 20 orders was achieved.

Part C. General Activity and Behavioural Characteristics

Apparatus

Observations were made in a 2.0 x 2.0 x 0.3 m arena with a wire mesh lid. The floor of this was raised so that illumination could be provided by four 40 W fluorescent tubes through the heavy translucent glass base. This base (floor) was divided into 0.3 x 0.3 m squares by a series of black lines. The remainder of the room was in darkness. While the observations were made a masking noise of 40 db was used to prevent distractions from adjoining rooms. A 5-sec auditory time-sampler regulated observations and the number of lines crossed by the front two feet of each animal was recorded with a manual counter.

Procedure

This was a direct application of the Bindra-Blond (1958) time-sample technique for recording general activity and its components. Each animal was habituated to the apparatus for 3 days for 1 h a day before measurements were taken. During this time five behavioural categories were selected with an inter-observer reliability of 95%. The subsequent categories and definitions were:

Ambulatory - two or more feet moving;

Rearing - two front feet off the ground;

Immobile - no feet moving and no head movement;
Grooming - the head region in contact with some other part of the body;
Other - any behaviour not categorised above.

Each animal was observed daily over 7 days for a 15-min period. The measure of activity was the number of lines crossed by both front feet of the animal during the 15 min, while behavioural observations were made at 5-sec intervals. As far as possible each animal appeared equally often at each time of the day to control for any circadian rhythm effects.

Results

Part A.

The combined results for both rounds of the paired comparison competition may be seen in Table A.2. This shows that the results closely represent a perfect linear hierarchy. A Landau coefficient for linearity gave a value of $h = 0.92$ which confirms this supposition (Landau, 1951). It may be noted that one of the relationships was not decided and is, therefore, represented as a halved encounter. For the purposes of the Landau coefficient, which allows only for win or loss outcomes, this observation was counted as acting against linearity.

A Coefficient of agreement (Kendall, 1962) was calculated between the two paired comparison rounds ($u = 0.62$, $p < 0.01$), which also demonstrated that the measures were reliable. A Kendall coefficient of concordance was determined for the pre-competition individual time measures. This proved to be significant ($w = 0.65$, $p < 0.01$) thus

demonstrating consistent individual differences in running speed. However a Spearman rank correlation between the rank order of these running speeds and the subsequent competitive order was extremely low ($r_s = 0.03$).

Part B.

A Kendall coefficient of concordance was applied to the 20 feeding orders obtained ($w = 0.56$, $p < 0.01$), demonstrating consistent individual differences in competitive performance. The resultant order is shown in Table A.3. Average time rankings for the 10 days were also subjected to this test ($w = 0.95$, $p < 0.01$) showing, for this apparatus, consistent individual differences in running speed. The resulting order for running speed may also be seen in Table A.3. A Spearman rank correlation calculated between this running speed order and the feeding order proved to be low ($r = 0.07$) indicating that this apparatus was also successful in establishing a hierarchy not based on running speed. The same test used between the paired comparison and feeding order hierarchies ($r = 0.68$) showed only a moderate correlation.

Part C.

A Kendall coefficient of concordance was calculated for the ranks of each ferret for each day on all of the behavioural categories. The results for this test are tabulated below:

General activity	$w = 0.81$	$p < 0.01$
Ambulation	$w = 0.29$	NS
Rearing	$w = 0.73$	$p < 0.01$
Immobility	$w = 0.67$	$p < 0.01$
Grooming	$w = 0.46$	$p < 0.01$

The resultant hierarchies can be seen in Table A.3. Spearman rank correlations were calculated between all hierarchies obtained, the results for these being shown in Table A.4.

While the paired comparison hierarchy did not correlate significantly with any of the other orders, the feeding order correlated positively with general activity and rearing, and negatively with grooming. The behavioural categories seemed to be classifiable into two groups: rearing and general activity; grooming and immobility.

Discussion

Both paired comparison and feeding order measures achieved a statistically meaningful hierarchy although the positive correlation between the two measures was not a significant one. Running speed did not prove to have a high relationship with either measure. This finding is comparable with those of Cole and Shafer (1966) who obtained competitive hierarchies in cats using two different testing conditions. In their study a low correlation was found between paired comparison competition orders in the W.G.T.A. and "Free Expression" dominance in which a group of eight cats competed for one food source. They suggested that the difference could have been due to the particular responses required, the spatial conditions imposed, or to the number of animals competing.

In the present study some degree of control over the first two variables was maintained, and it may be inferred that the comparatively low correlation between the two competitive orders is attributable to the differing numbers of animals competing. Thus it may be that the increase in the number of competitors caused a slight change in the social

requirements of the apparatus, and that social processes between pairs of animals could have been modified, at least slightly, within the whole-group context. A further possibility is that temporal fluctuations in the acquired order may have prevented an otherwise high correlation. However this is unlikely since the feeding order competition was conducted immediately after the paired comparison tests. An alternative explanation may exist; that different tests for these orders may yield different results even if the number of animals remains constant. This would suggest that our low correlation results from physical rather than social changes occuring because of the increase in the number of ferrets in the feeding order situation.

Changes in dominance measures due to differences in the physical requirements of competitive responses have already been demonstrated in monkeys (Hamilton, 1960); mice (Lindzey, Manosevitz and Winston, 1966); and rats (Syme and Pollard, 1972). If dominance measures in the ferret are affected by the application of differing competitive responses the concept of role, as advocated by Gartlan (1968) and Crook (1970) among others, may be more suitable for the description of social organisation in this species. It would then be conceptually permissible for the social organisation of a group of ferrets to alter according to the environmental circumstances.

The feeding order obtained was significantly correlated either positively or negatively with all behavioural categories except immobility. A high positive correlation was found between general activity and the feeding order. The same relationship existed between rearing and the feeding

order. However a significantly negative relationship was found between grooming behaviour and this same order. The paired comparison order was not significantly correlated with any of the general behavioural characteristics. In finding a significant correlation between general activity and feeding order this study contrasts with the results of Lester (1967) who found no difference in activity between dominant and submissive rats. The discrepancy could be attributed, however, either to the different species used or to the particular dominance measures employed.

The sex variable has been ignored in the present study although it was noted that, during paired comparison testing, unreliable relationships occurred between male and female ferrets rather than between same-sex pairs. Although general pen observations of these animals outside the breeding season suggest few systematic differences in behaviour, comparisons between male and female subjects should be examined in future studies.

Summary

Two competitive orders were established for a group of seven ferrets using paired comparison and whole-group measures. One should not conclude, though, that Poole's descriptions of aggressive behaviour (1966, 1967, 1972) have been merely simplified into a unidimensional competitive measure of dominance. What has been shown is the feasibility of measuring linear competitive orders in the New Zealand ferret. The full social interpretation of such orders awaits further investigation.

TABLE A.1

Details of experimental subjects.

Subject	Sex	Litter
1	M	1
2	F	2
3	F	3
4	F	1
5	F	2
6	M	1
7	M	3

TABLE A.2

Performance of each animal in paired comparison competition; results for each pairing over 20 trials. A + sign indicates that the animal represented in the row won the reward in more than 10 of the 20 trials against the animal represented in the column, while a ½ sign represents a drawn encounter.

Subjects	1	2	3	4	5	6	7
1	-	+	½		+	+	+
2		-	+	+	+	+	+
3	+		-	+	+	+	+
4	½			-	+	+	+
5					-	+	+
6						-	+
7							-

TABLE A.3

Rankings of each ferret on all hierarchies. Body of the table contains subject numbers as in Table A.1. P - paired comparison, F - feeding order, A - general activity, G - grooming, R - rearing, I - immobility, TP - running times in paired comparison, TF - running times in feeding order apparatus.

Rank	P	F	A	G	R	I	TP	TF
1	1	4	2	7	2	7	4	3
2	2	2	4	6	5	6	5	2
3	3	1	5	3	1	4	6	1
4	4	5	1	5	4	3	1	6
5	5	3	3	2	3	1	2	4
6	6	6	6	1	6	2	3	5
7	7	7	7	4	7	5	7	7

TABLE A.4

Matrix of correlations between all hierarchies. P - paired comparison, F - feeding order, A - general activity, G - grooming, R - rearing, I - immobility, + - significant at the 5% level, ++ - significant at the 1% level.

	P	F	A	G	R	I
P	-	0.68	0.61	-0.54	0.60	-0.56
F		-	0.93^{++}	-0.96^{++}	0.75^{+}	-0.54
A			-	-0.82^{+}	0.89^{++}	-0.714^{+}
G				-	-0.75^{+}	0.52
R					-	-0.93^{++}
I						-